

# CNS Trauma: Radiologic-Pathologic Correlation

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Learning to Care for Those in Harm's Way

# Uniformed Services University Bethesda, MD

# CNS TRAUMA

- IMPACT
  - CONTACT INJURY
  - scalp/skull Abnormal
- INERTIAL
  - NON-CONTACT INJURY
  - acceleration/deceleration
  - scalp/skull Normal

# Types of Injury

- Primary Lesions
  - Contusions
  - Shearing Injury
- Secondary Lesions
  - Mass Effect
  - Increased ICP
  - Herniation
  - Infarction

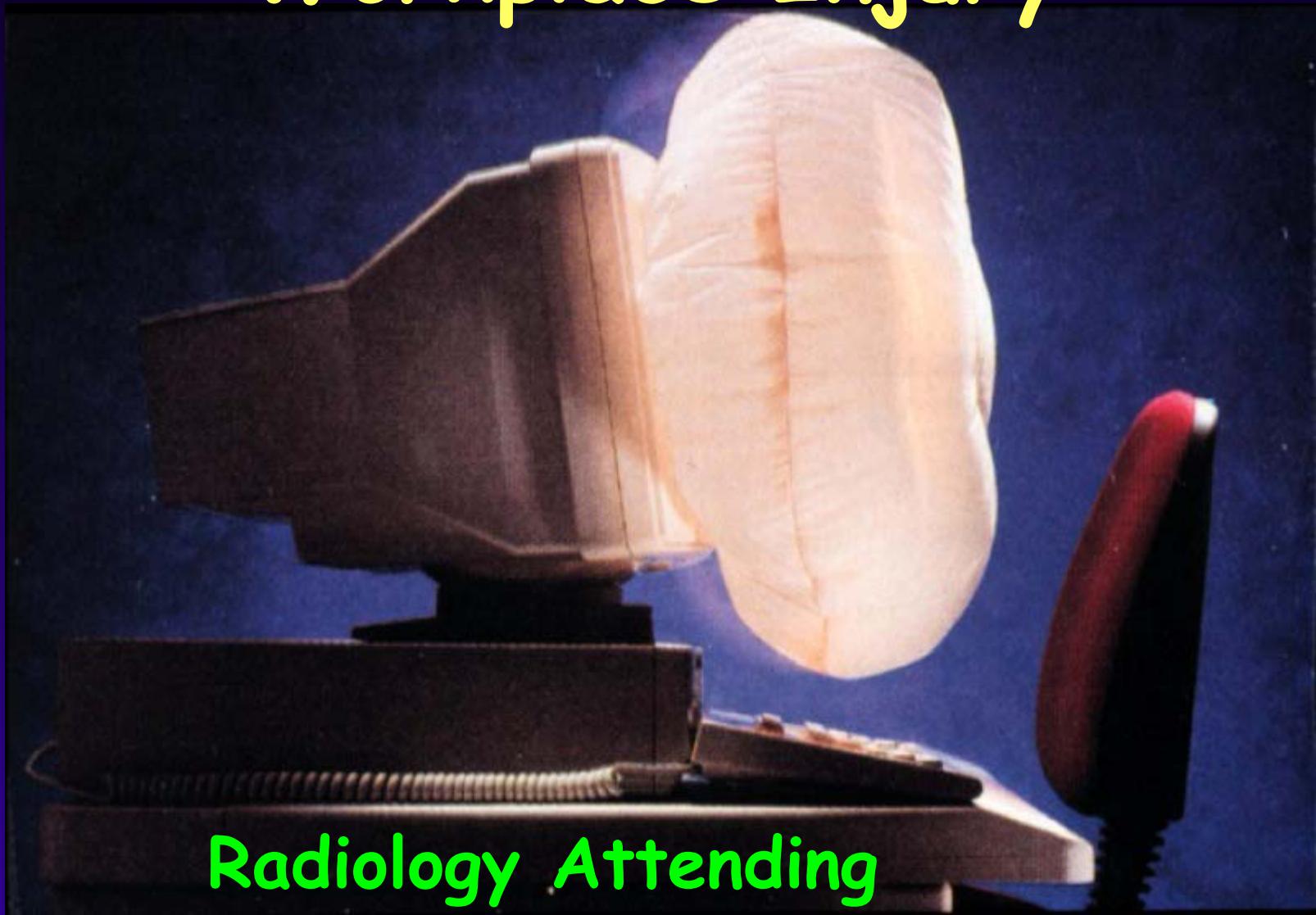
# Recreation Injury



# Roller Coaster Headache

- Roller Coasters can create 2.5 - 3 G's
- Grandpa rides with Granddaughter
  - She's screaming with excitement
  - He's subdued by Subdural
- Reference:  
**Fukutake T, Mine S, Yamakami I, Yamaura A, Hattori T.**  
**Roller coaster headache and subdural hematoma.**  
**Neurology. 2000 Jan 11;54(1):264.**  
**PMID: 10636168; UI: 20100123**

# Workplace Injury



Radiology Attending

# Relative Sensitivity

- MR Spectroscopy (decreased NAA)
- Magnetization Transfer Ratio
- Apparent Diffusion Coefficient
- Diffusion Weighted Imaging
- FLAIR
- Convention SE MR (T2W > T1W)
- CT (ECT > NCT)
- Skull Radiogram

# Reasons for Getting an MR

- CT fails to explain Pt's Condition

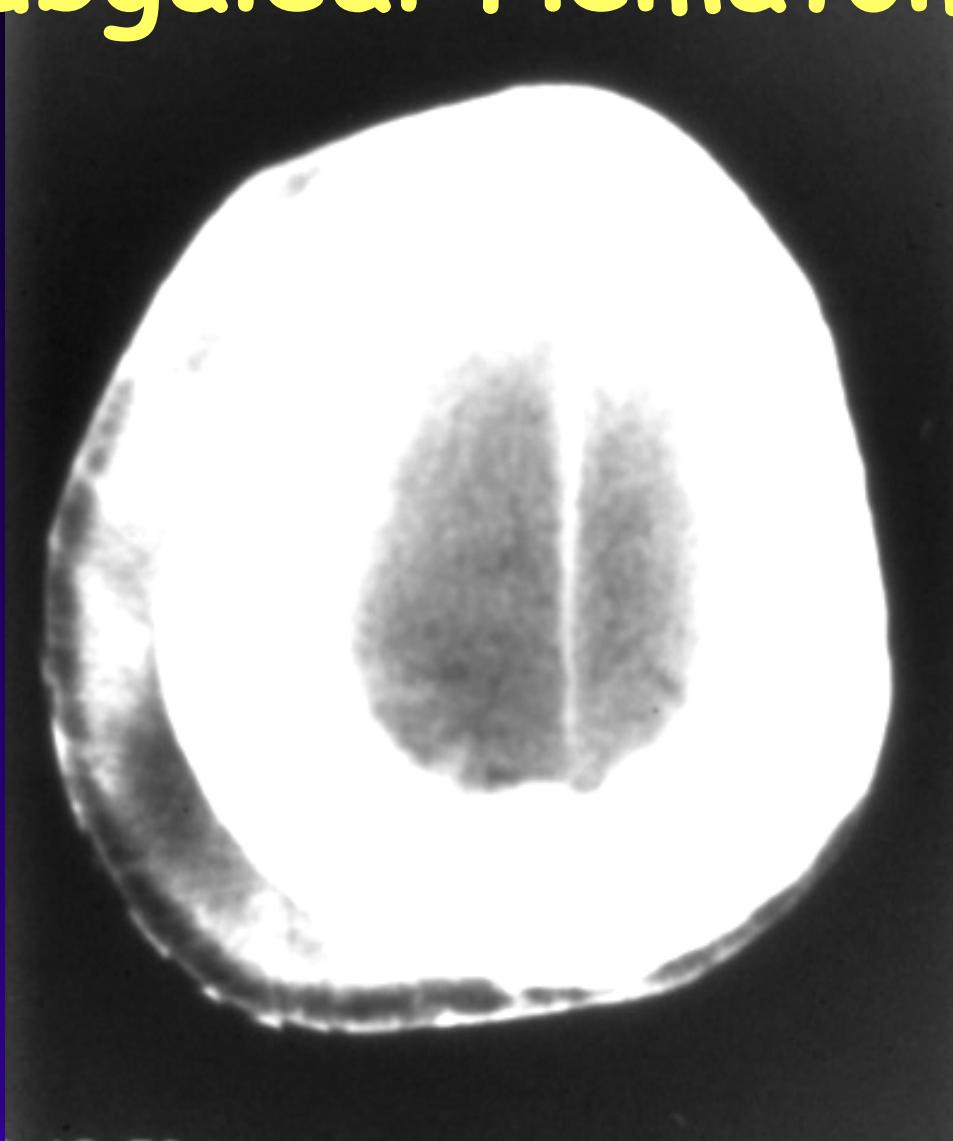
# CENTRIPETAL APPROACH

- SCALP
- CALVARIUM
- EPIDURAL
- SUBDURAL
- SUBARACHNOID
- INTRA-PARENCHYMAL
- INTRA-VENTRICULAR

# CNS TRAUMA -- SUBGALEAL

- Between periosteum of OUTER table and the GALEA (under scalp fat)
- In CHILD, significant blood loss
- Spontaneous decompression of intracranial (Epidural) hematoma

# Subgaleal Hematoma





# Linear Skull Fx

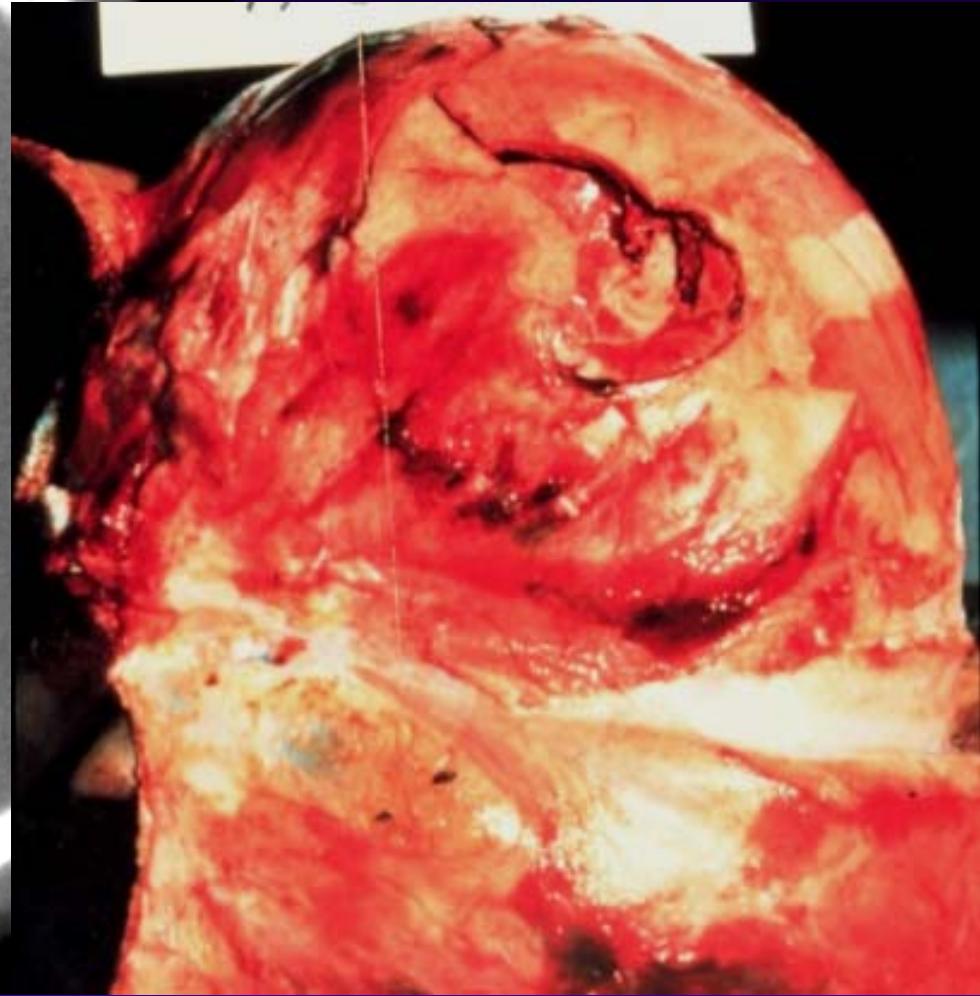
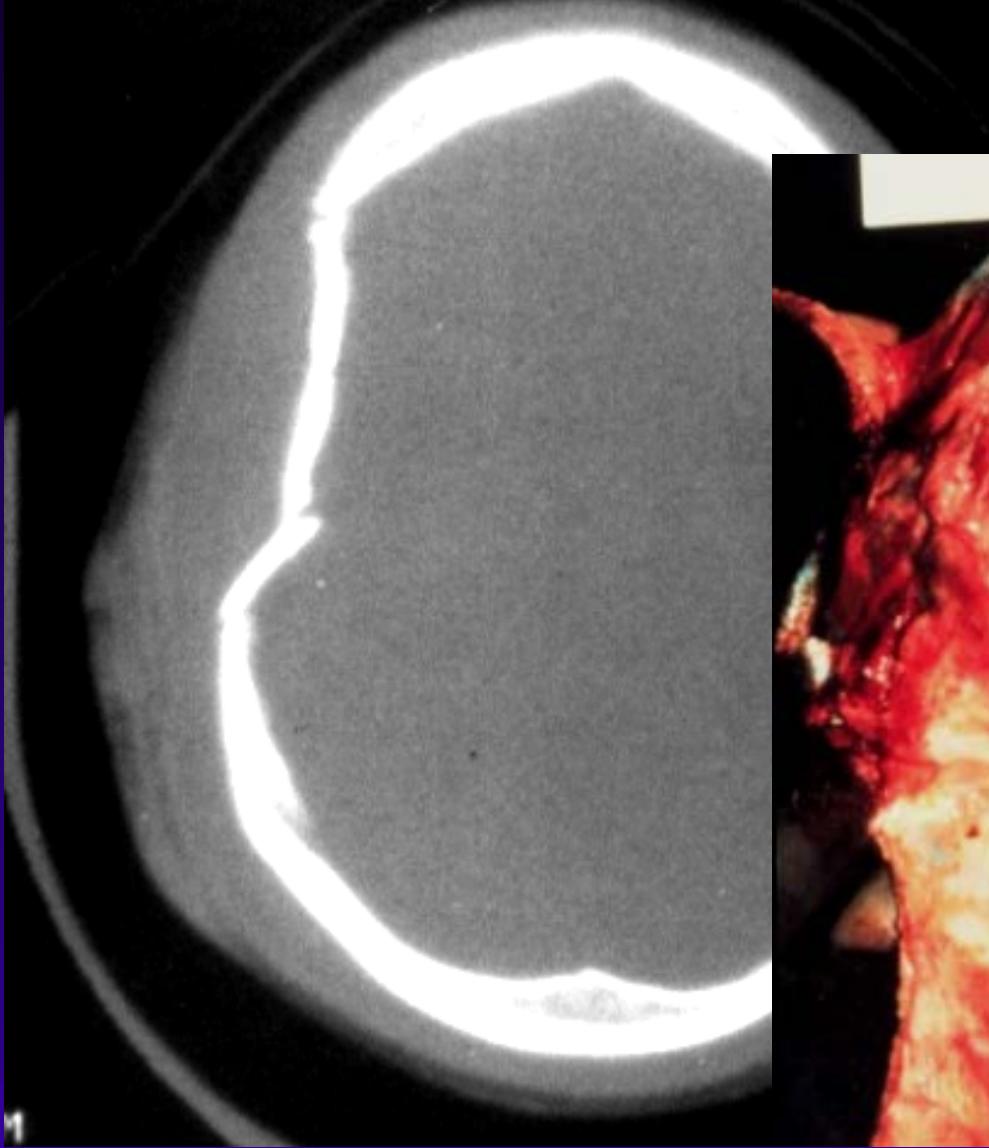


# Depressed Skull Fx

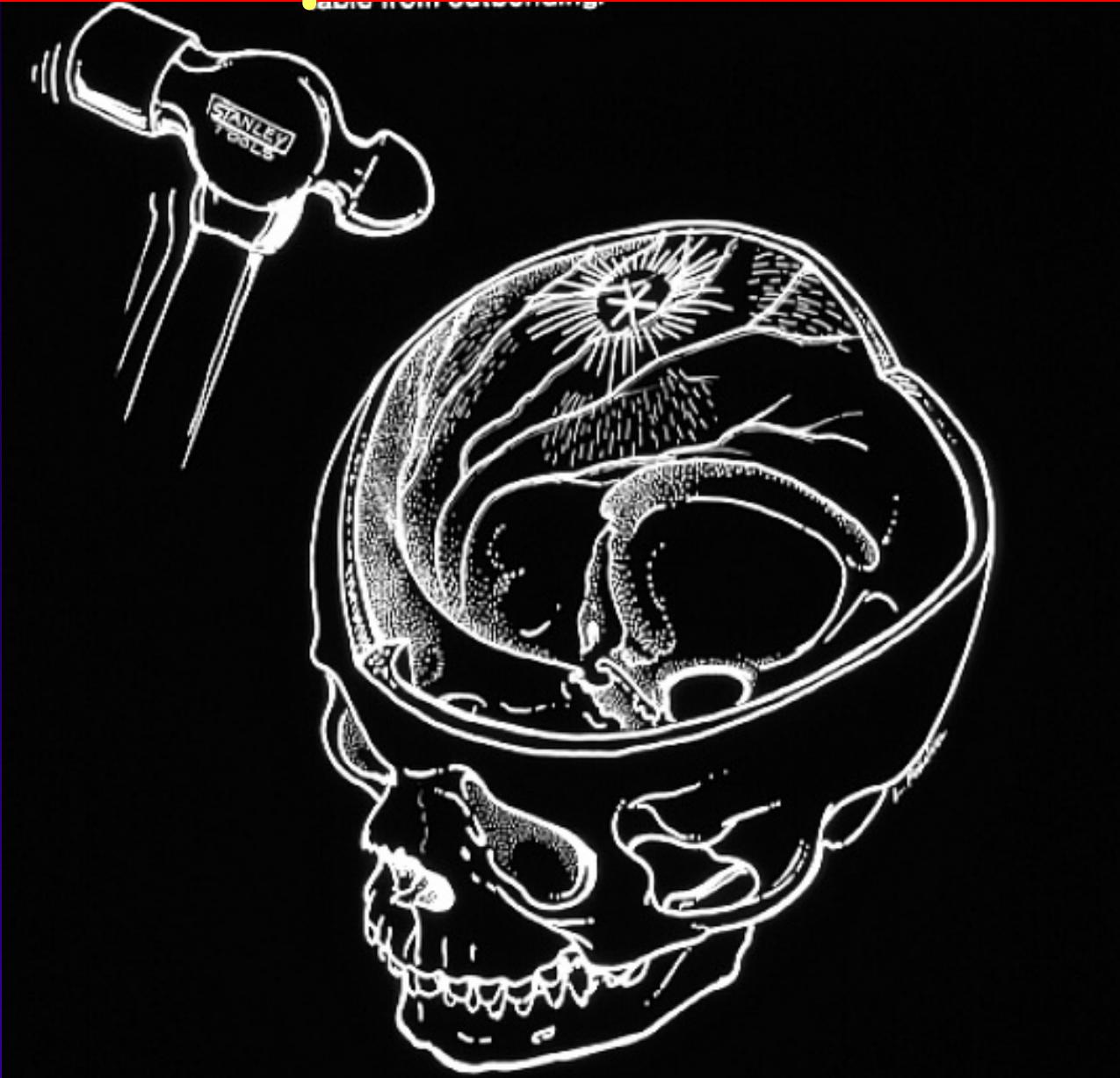


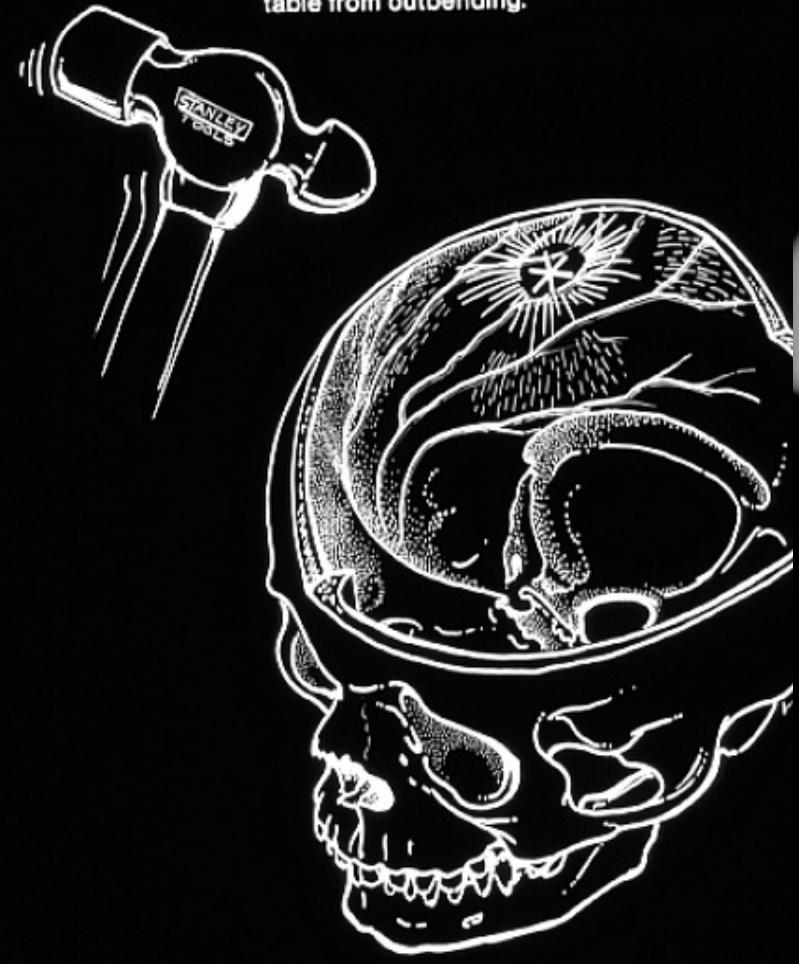
.5MM

# Depressed Skull Fx



# Ballpeen Hammer





A... Towne Project... Uninterrupted lines run out from point of impact (asterisk) represent cracks in bone from inbending. Interrupted lines are cracks in bone from outbending.



# MEMBRANE HEMATOMAS:

- SUBGALEAL
- SUBPERIOSTEAL OUTER TABLE
  - (CEPHALOHEMATOMA)
- SUBPERIOSTEAL INNER TABLE
  - EPI (EXTRA) DURAL
- Subdural ('epi-arachnoid')
- SUBARACHNOID
- PARENCHYMAL HEMATOMA
- INTRA-VENTRICULAR

# CNS TRAUMA EPIDURAL HEMATOMA

- Young men (20-40's)
- Acute presentation
- Skull fracture (90%)
- Bi-convex, hyperdense- limited by sutures

# EPIDURAL HEMATOMA - Source of Bleeding

- MENINGEAL VESSELS
  - Arterial (high pressure)
  - Venous (low pressure)
- DURAL SINUS
  - High flow, low pressure
- OTHER
  - Diploic veins (Fx)
  - Marrow sinusoids

# EPIDURAL HEMATOMA

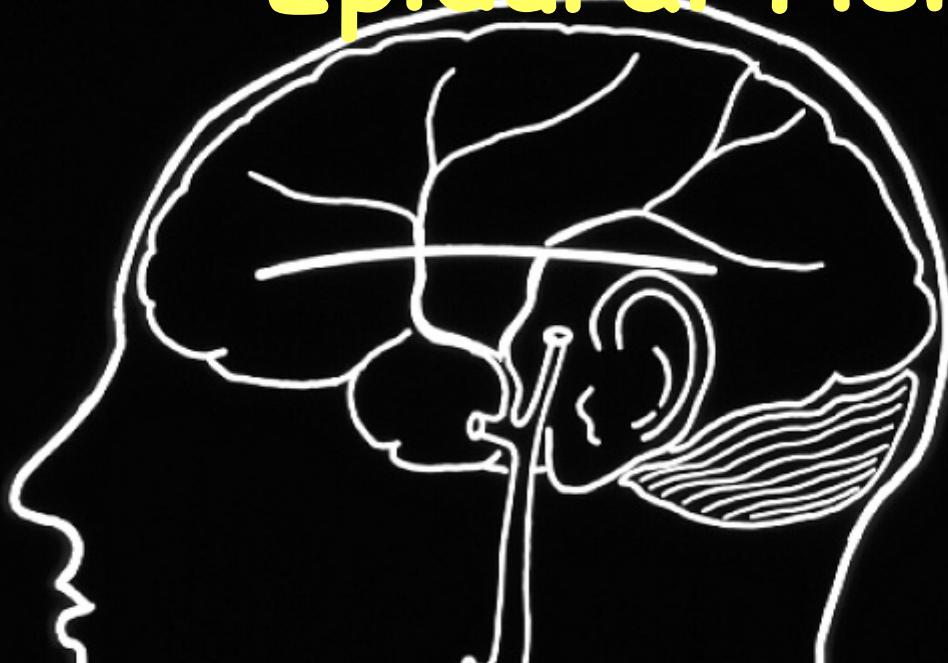
- Significant trauma
- Fracture & concussion (l.o.c.)
- Wakes up (lucid interval - 40% pts.)
- Delayed neurologic Sx (hrs. Later)
- Herniation, coma and death

# EPIDURAL HEMATOMA

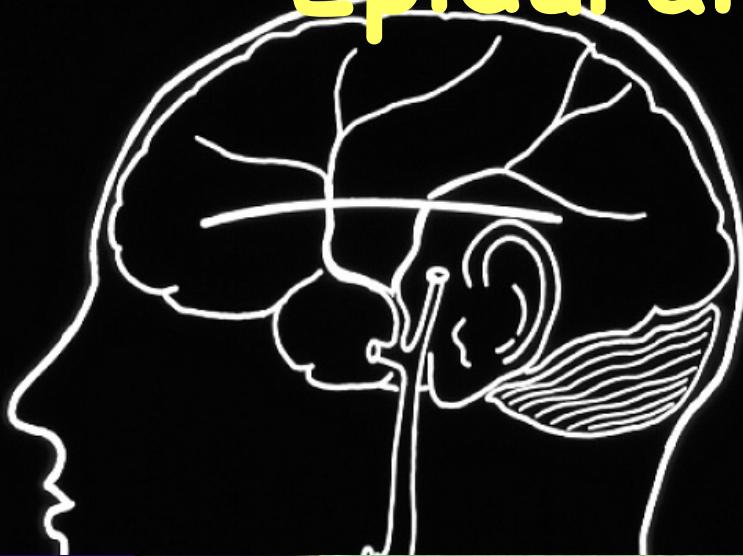
- Trauma -> fracture & concussion
- Tearing/stripping of both layers from inner table
- Laceration of outer periosteal layer
- Laceration of meningeal vessels
- Inner (meningeal dura) intact
- Blood between naked bone and dura



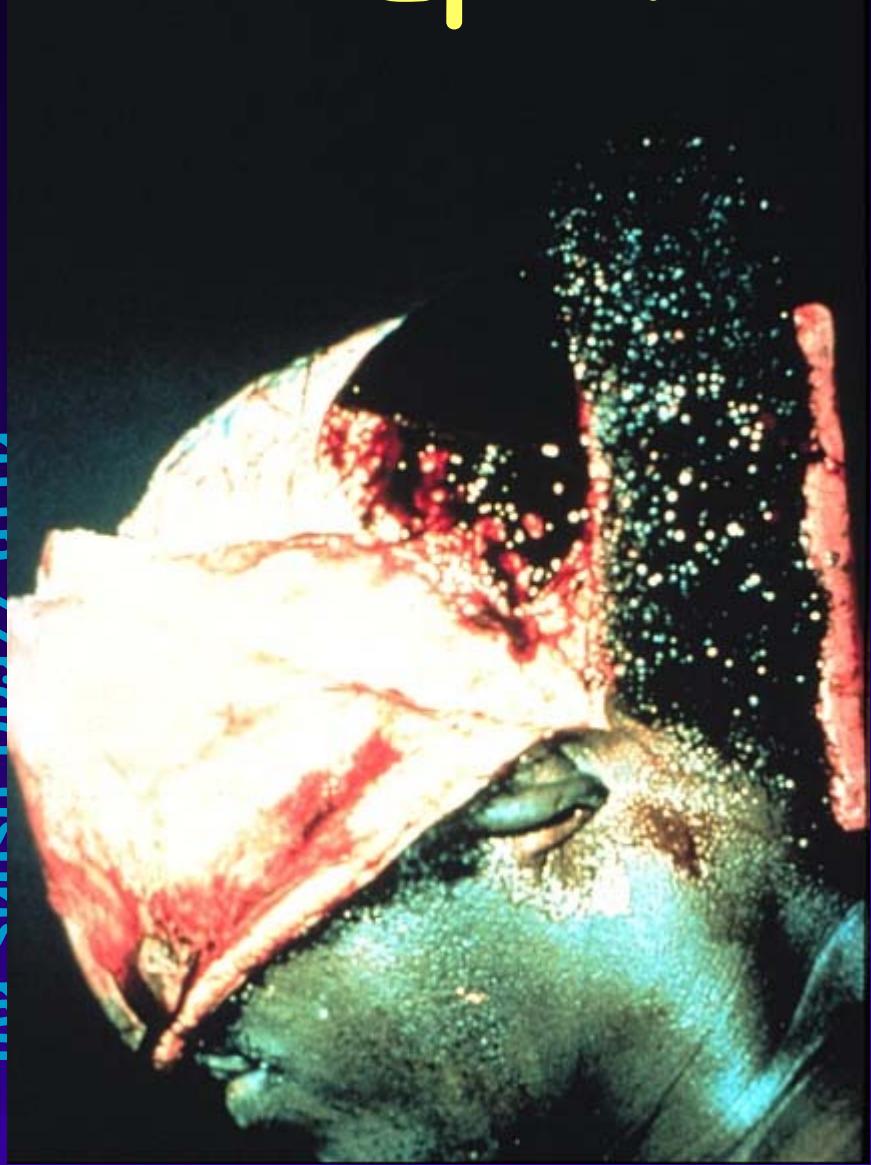
# Epidural Hematoma

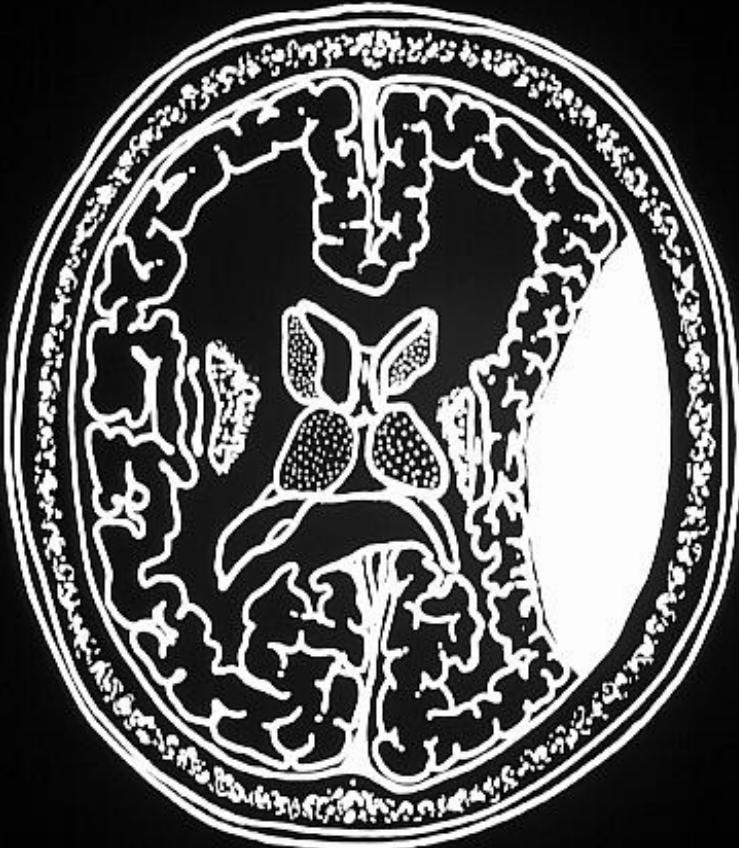


# Epidural Hematoma



# Epidural Hematoma





iSpeed Adv SYS#CT02  
654  
77.5  
4  
20.0cm  
V/I

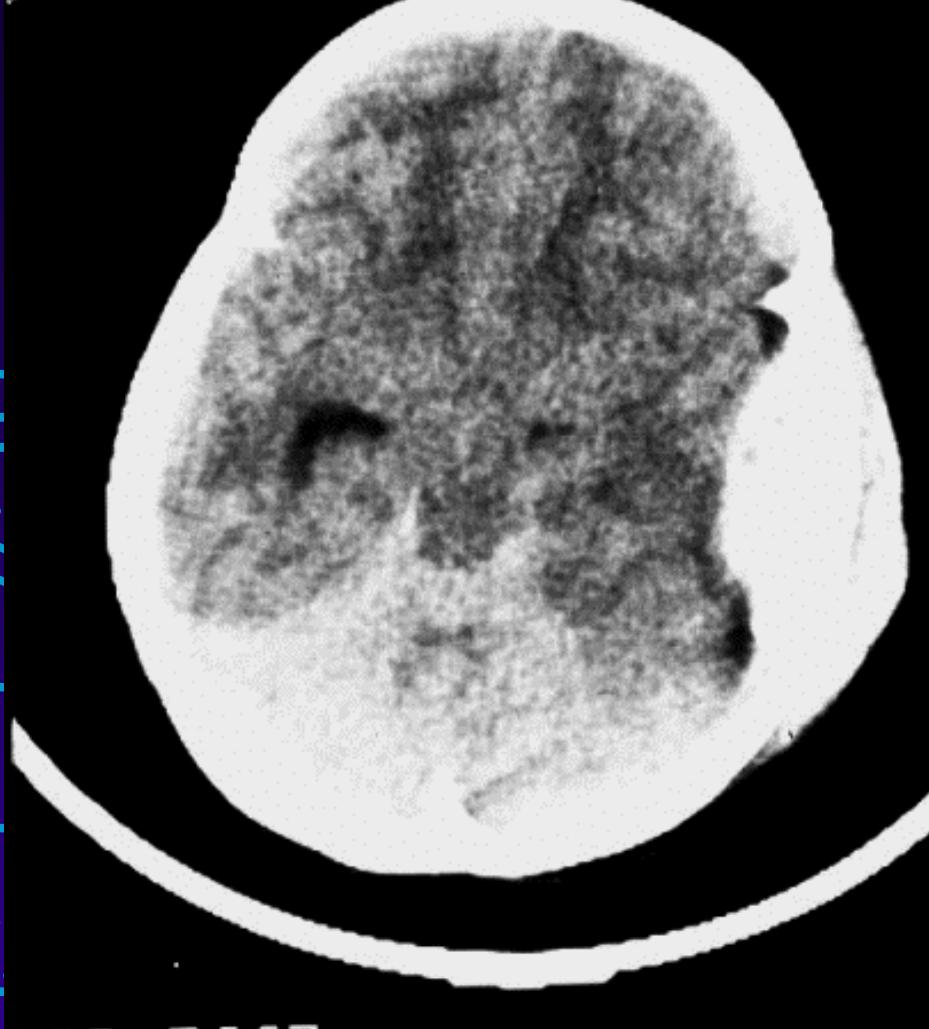
Naval Medi

100  
200~  
nt mA 199  
Head  
m  
t -1 0  
s 01:22:27

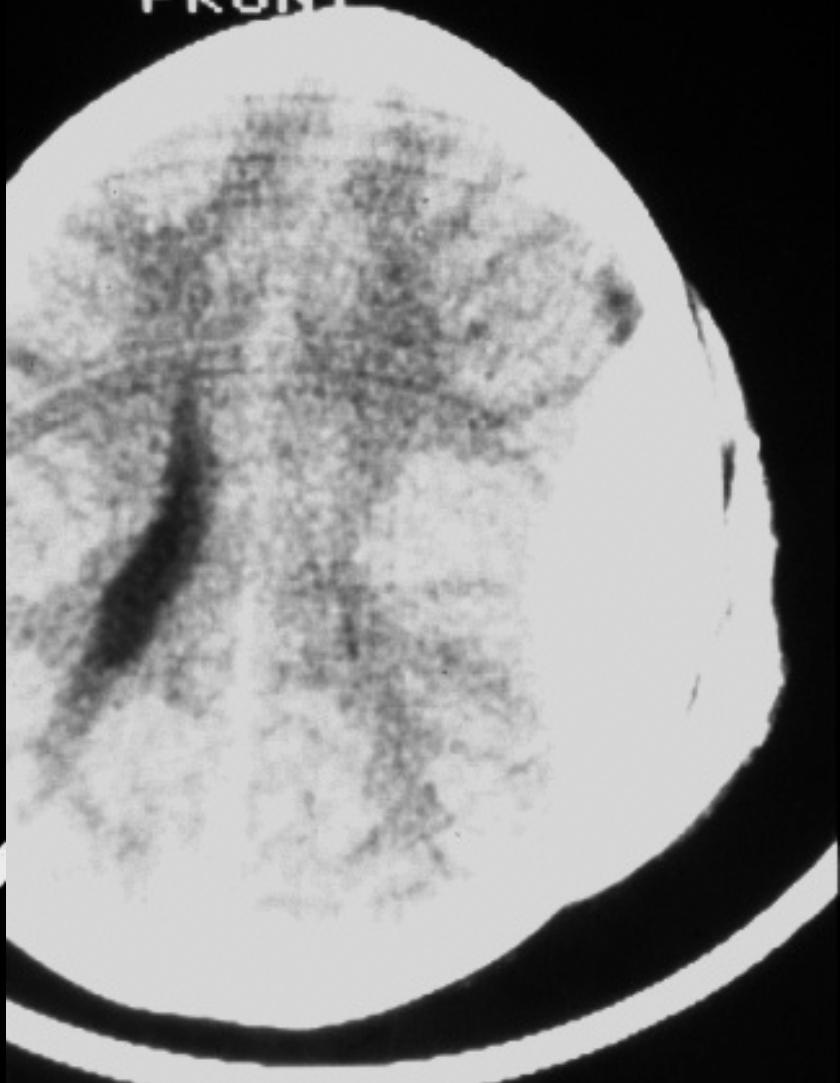


# Epidural Hematoma

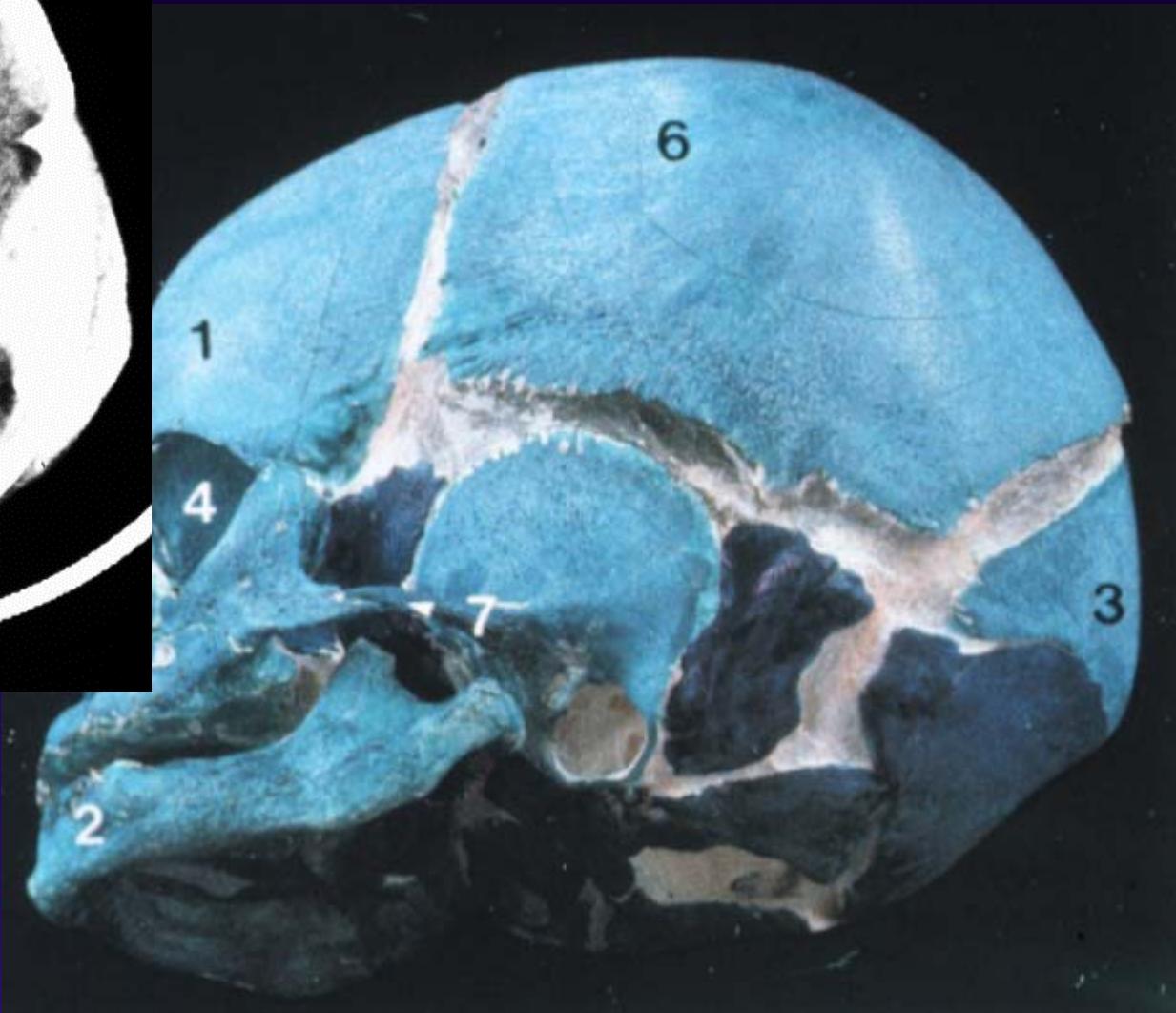
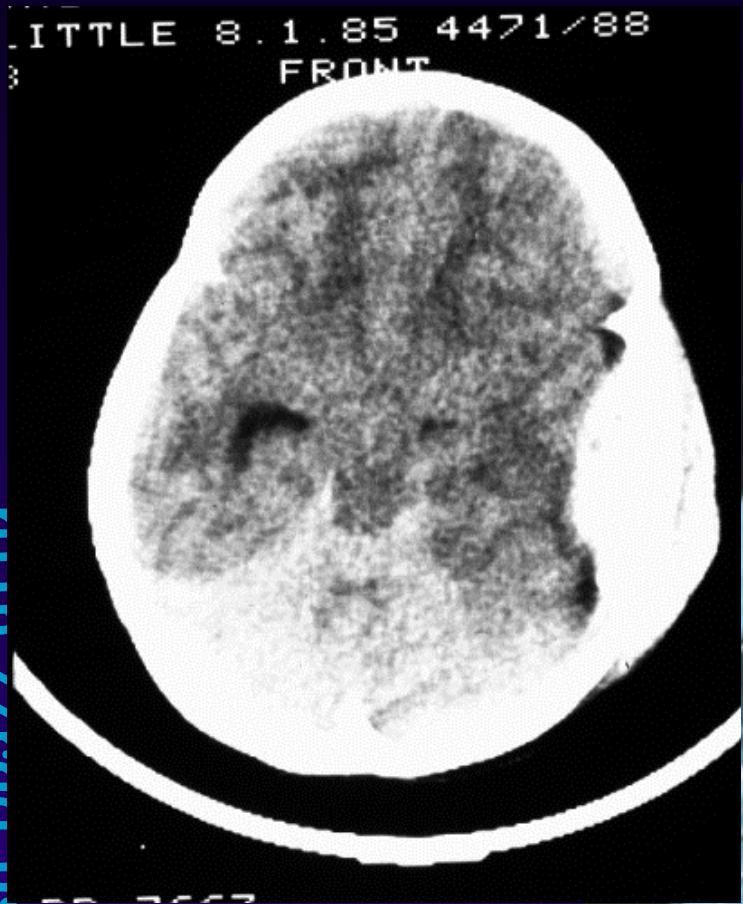
LITTLE S. R. 5/14/88  
FRONT



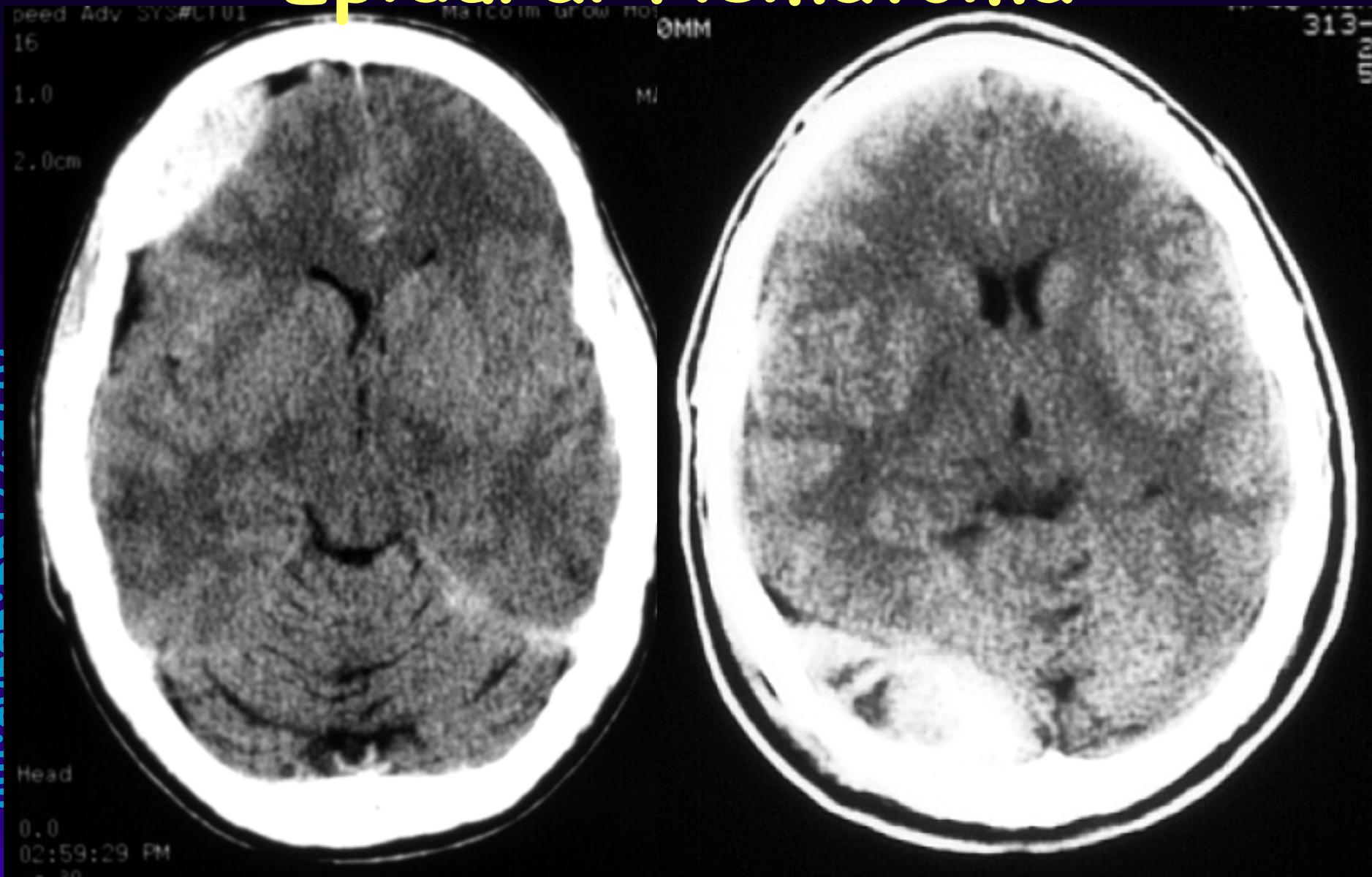
FRONT



# Epidural Hematoma



# Epidural Hematoma



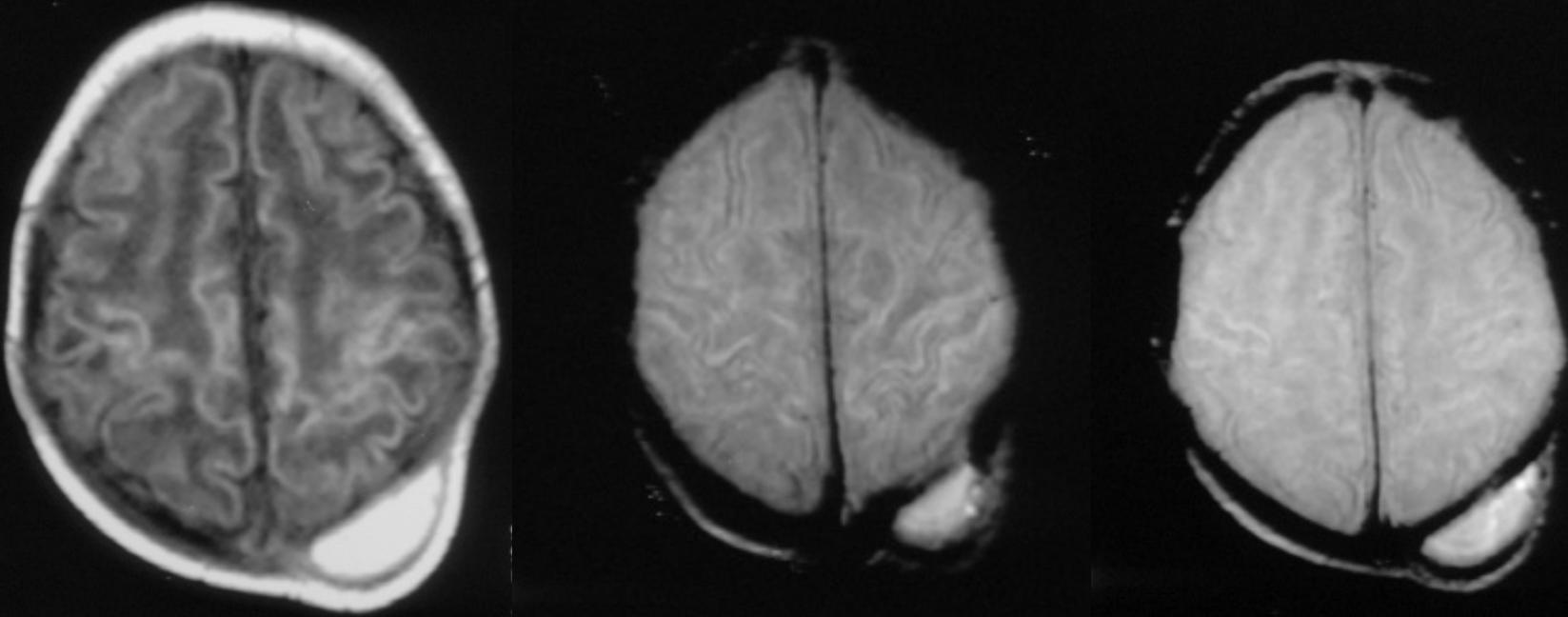
# Progressive EDH



# SUPERIOR SUBPERIOSTEAL HEMATOMA

- CEPHALOHEMATOMA
  - (Birth trauma)
  - (outer table, sub-periosteal)
- EPIDURAL HEMATOMA
  - (Inner table, "sub-periosteal")

# Cephalohematoma Birth Trauma



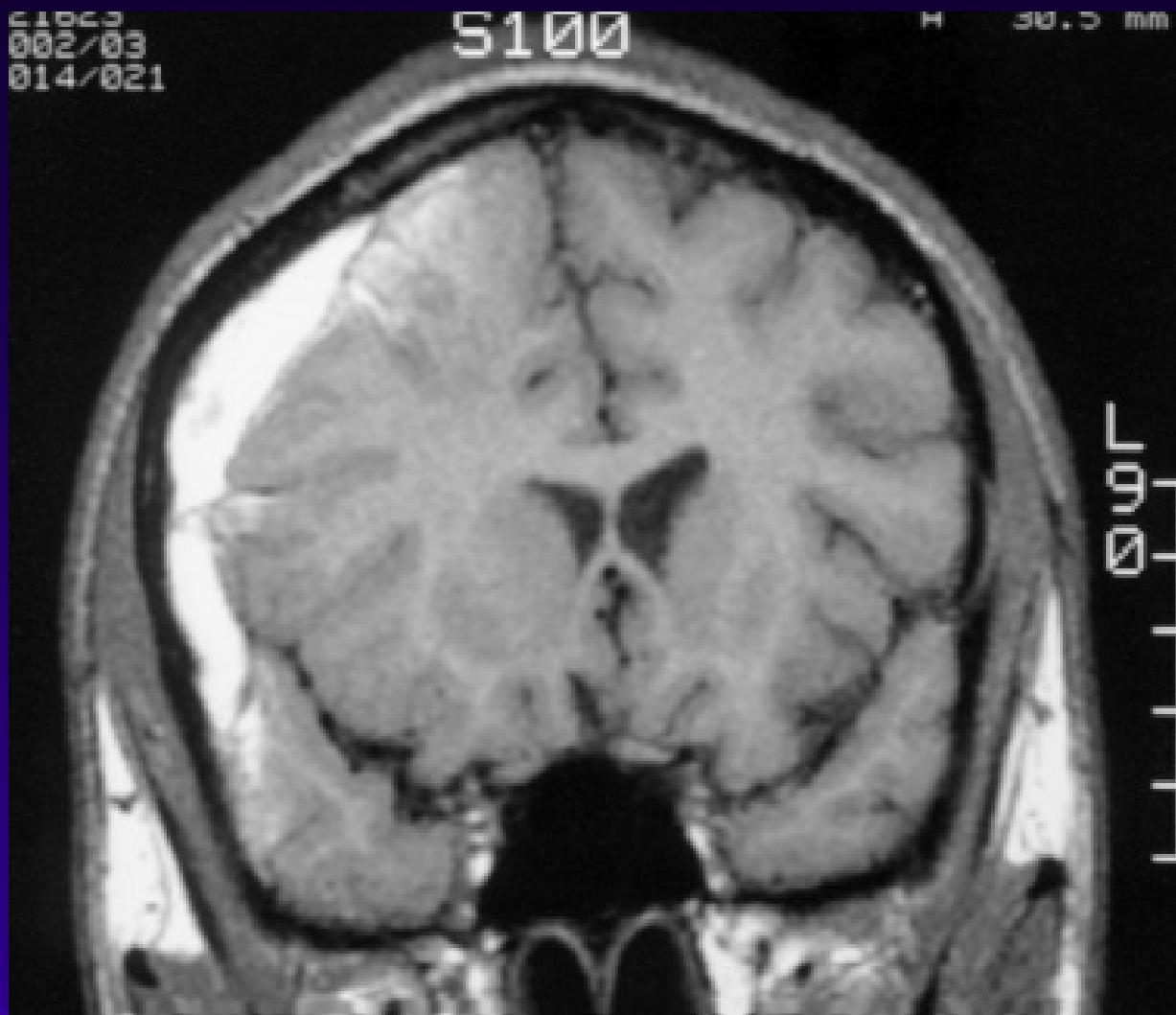
# SUBDURAL HEMATOMA

- Extremes of age
  - Infants/elderly
- Subacute presentation
  - Days or weeks after trauma
- Fracture not needed
- Crescentic
  - Not hyperdense
  - Crosses sutures commonly
  - Interhemispheric fissure (kids)
- Epi - Arachnoid

# SUBDURAL HEMATOMA - Source of Blood

- LACERATION OF CORTICAL AA. AND VV
  - (Direct: penetrating injury)
- LARGE CONTUSIONS
  - (Direct/indirect: "pulped brain")
- TORN BRIDGING (CORTICAL) VEINS
  - (Indirect: acceleration-deceleration)

# Subdural Hematoma



# SUBDURAL HEMATOMA

- ACCELERATION-DECELERATION
  - Causes OSCILLATION OF BRAIN
  - Movement of Brain LAGS behind Skull
- BRIDGING VEINS STRETCH & TEAR
  - Venous bleeding (slow)
- DISSECTION OF SUBDURAL SPACE
  - Under Dura - Over Arachnoid
- Hematoma spreads around convexity
- Into the interhemispheric fissure (child)

# Bridging Veins - Slack



# Bridging Veins - Tension



# Bridging Veins - Tension



# Bridging Veins - Tear



# Subdural Hematoma



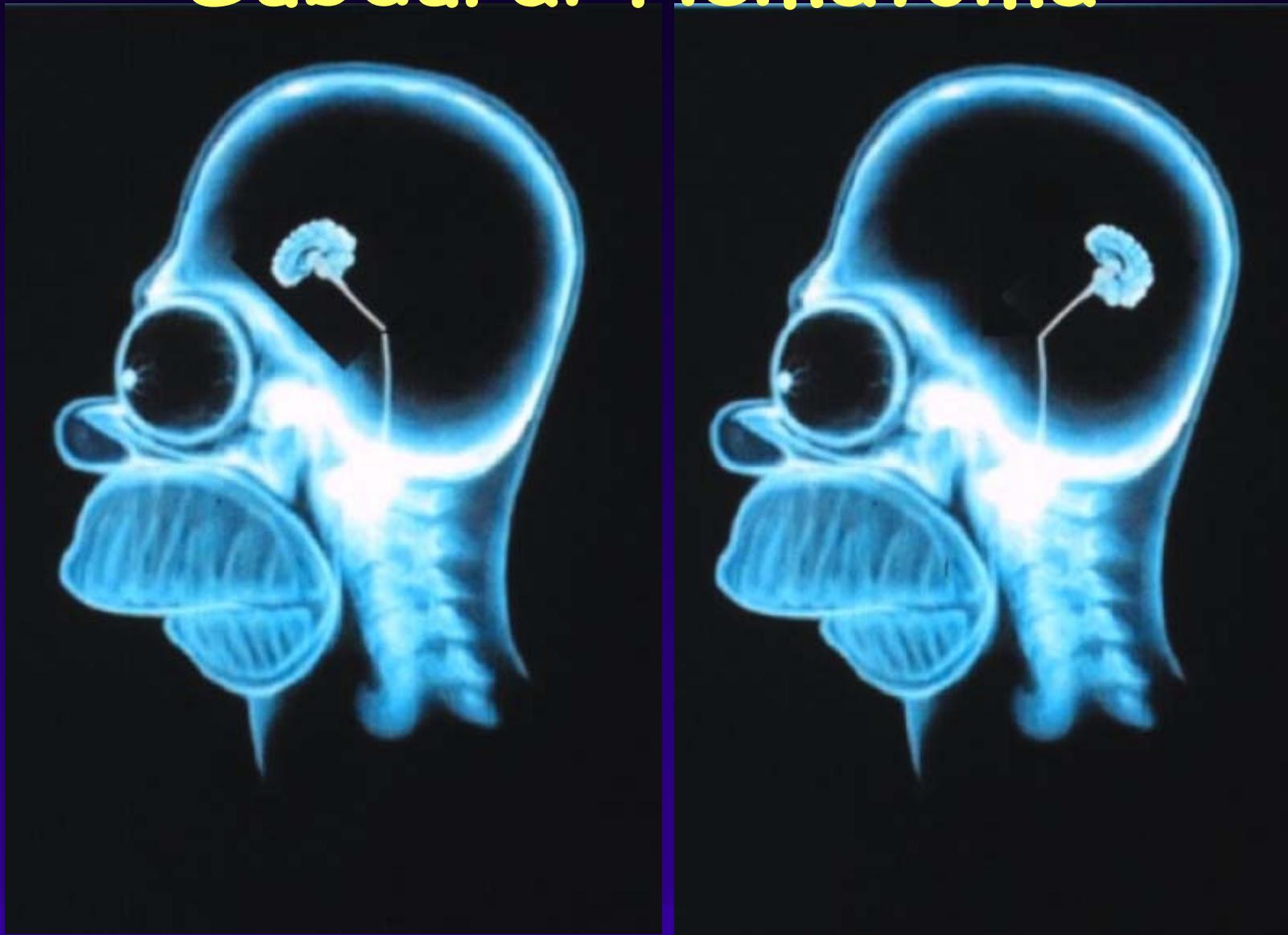
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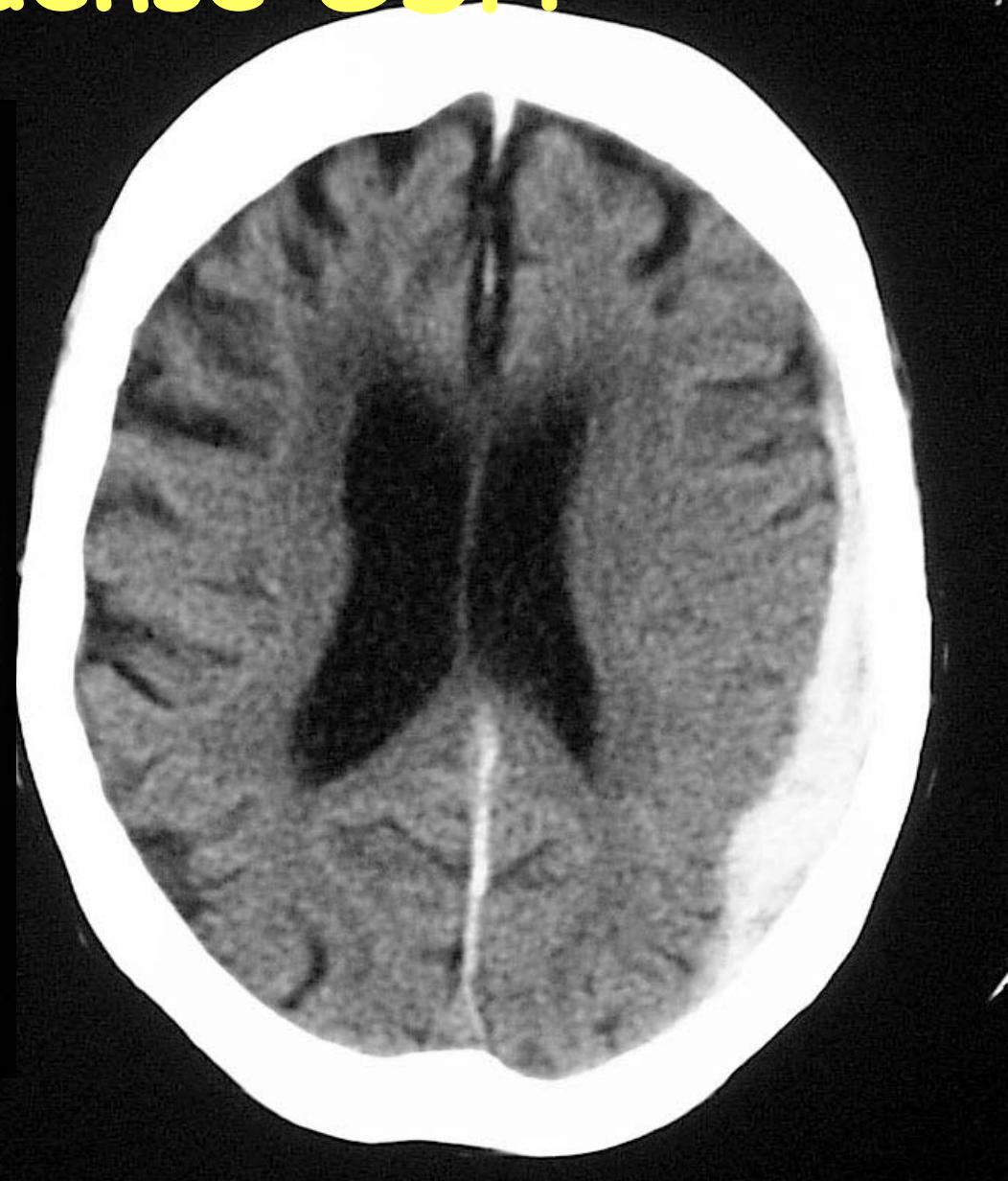
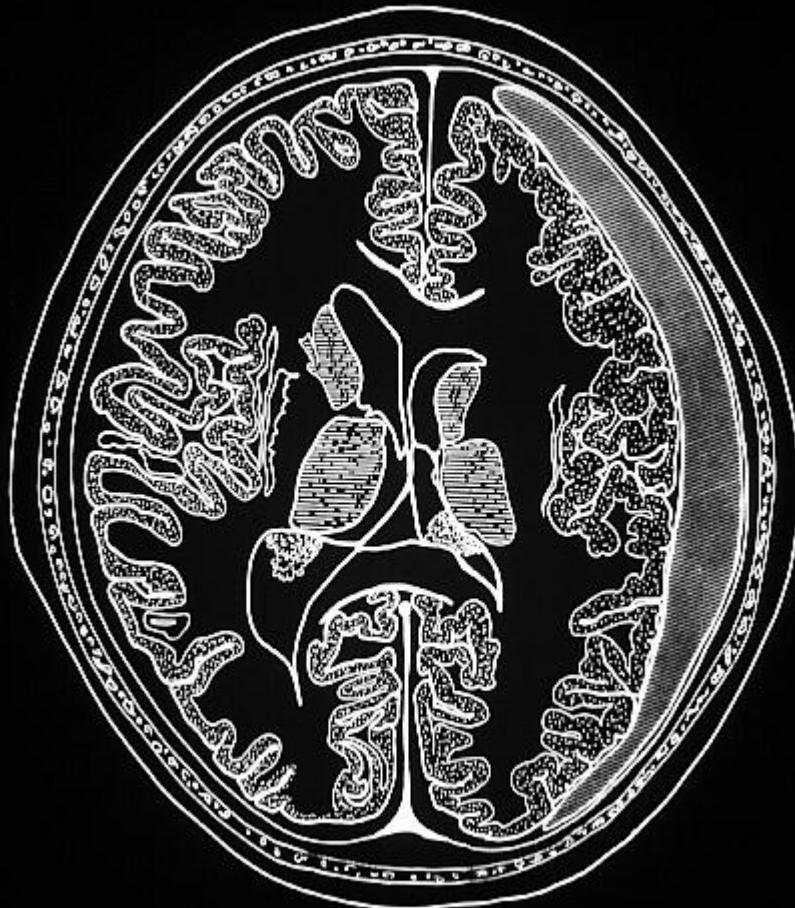
KODAK LATEX MEDIUM

H.J. SIMPSON

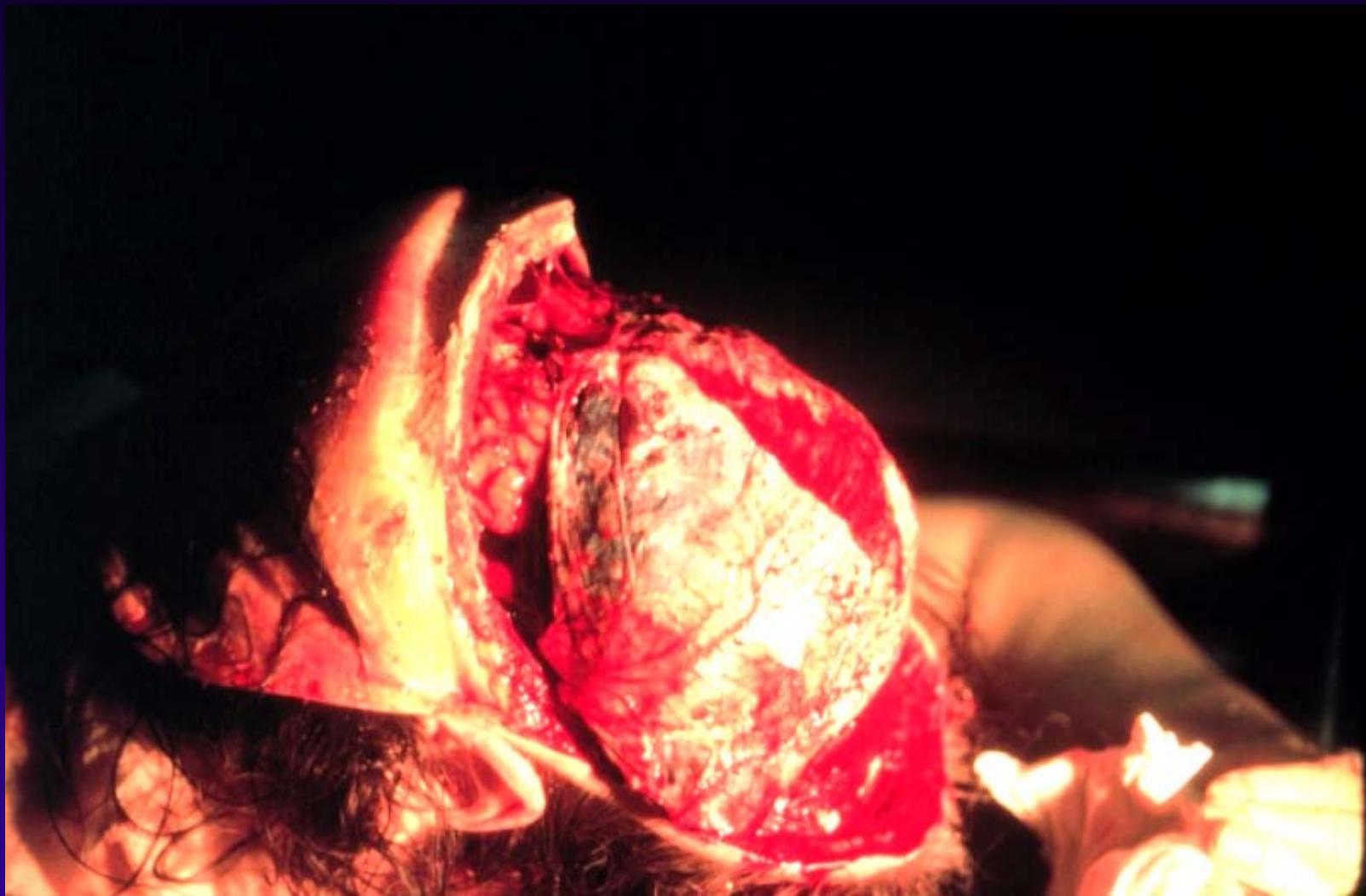
# Subdural Hematoma



# Hyperdense SDH



# Subdural Hematoma



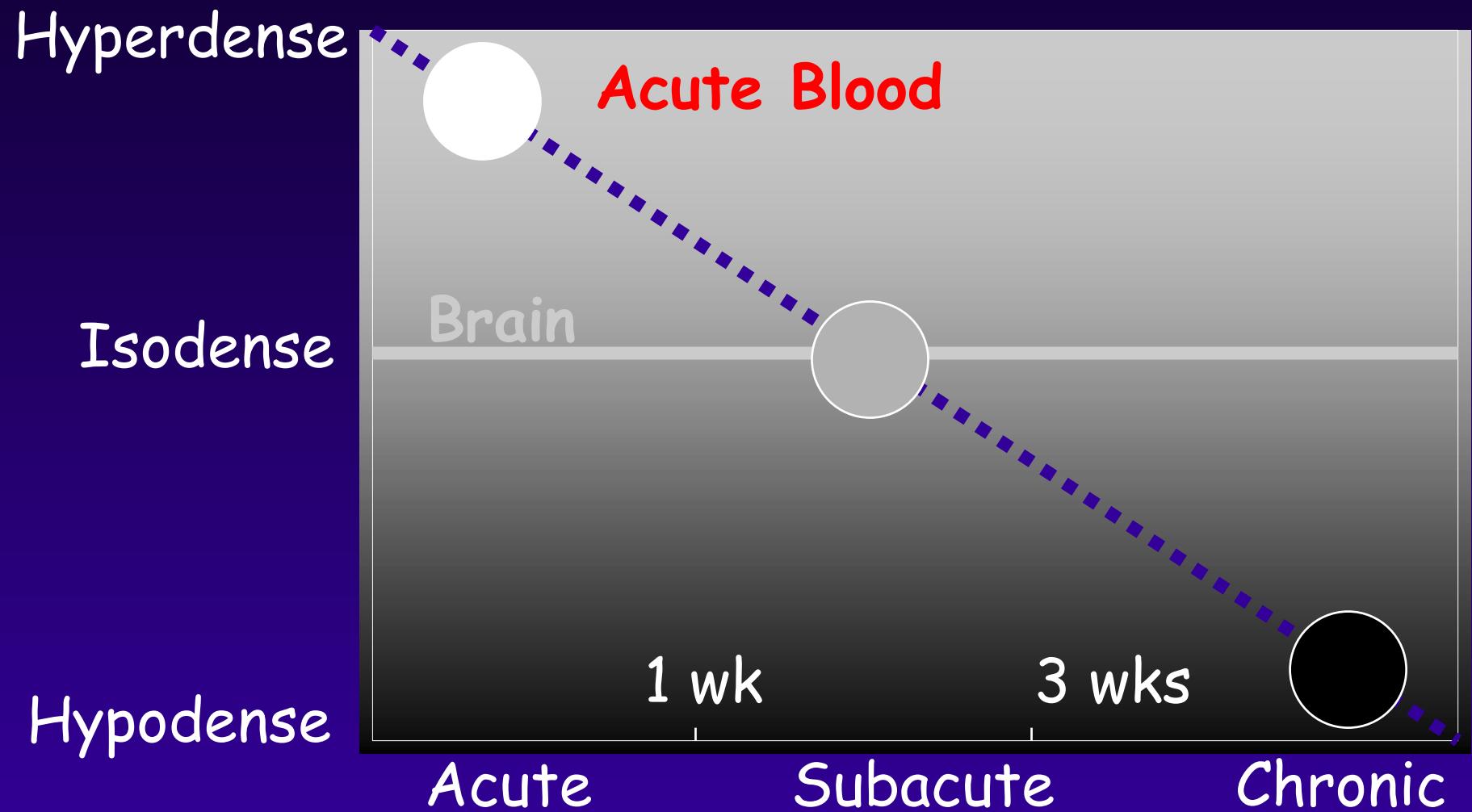
# Subdural Hematoma



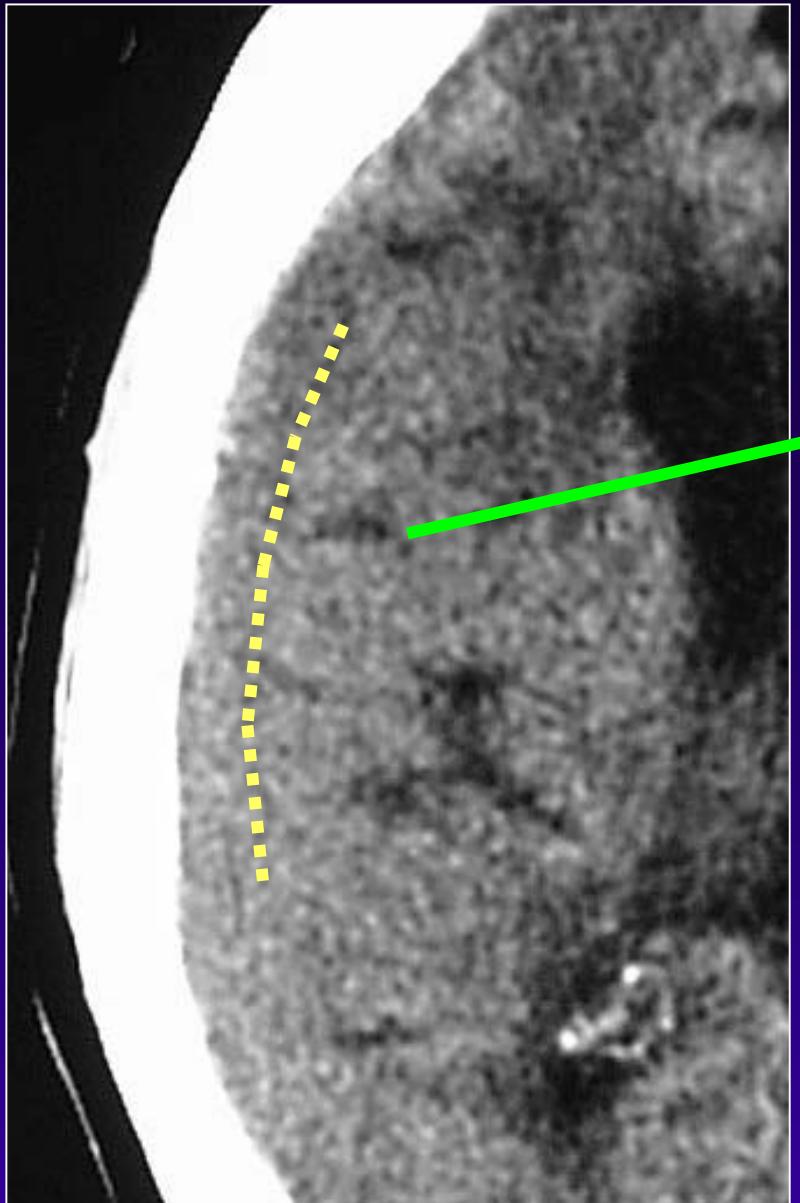
# SUBDURAL HEMATOMA

- ACUTE (0-7 days)
  - HYPERDENSE (65-90 Hu)
- SUBACUTE (7-22 days)
  - ISODENSE (20-40 Hu)
- CHRONIC (>22 days)
  - HYPODENSE (0-20 Hu)

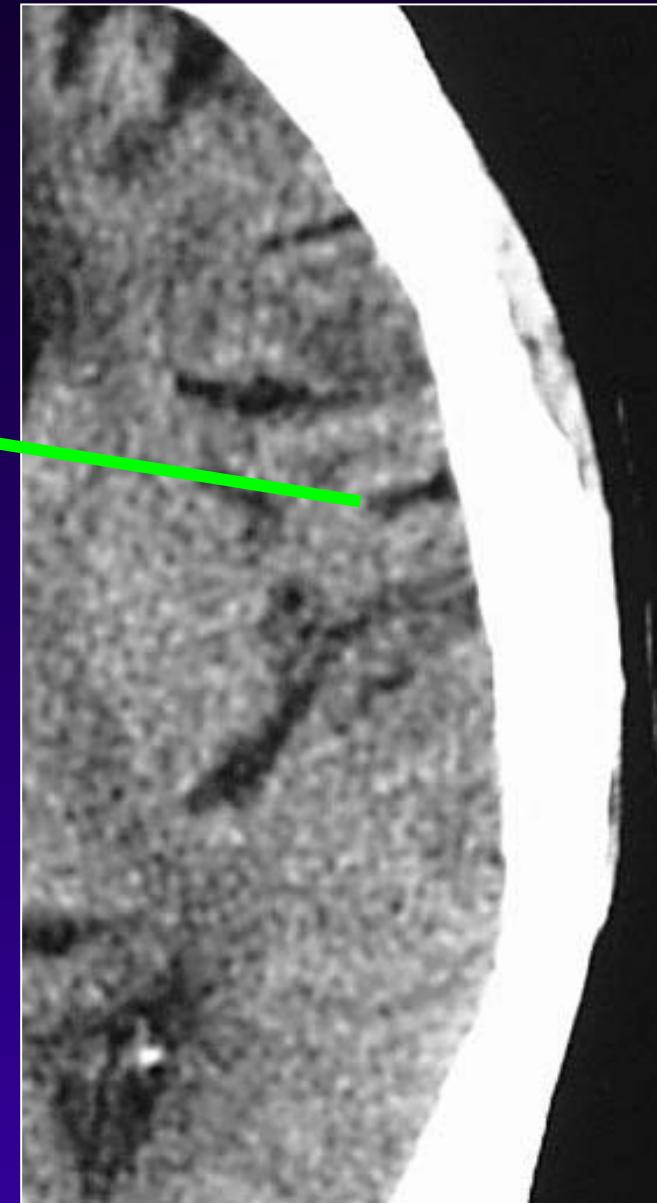
# Hemorrhage: change over time



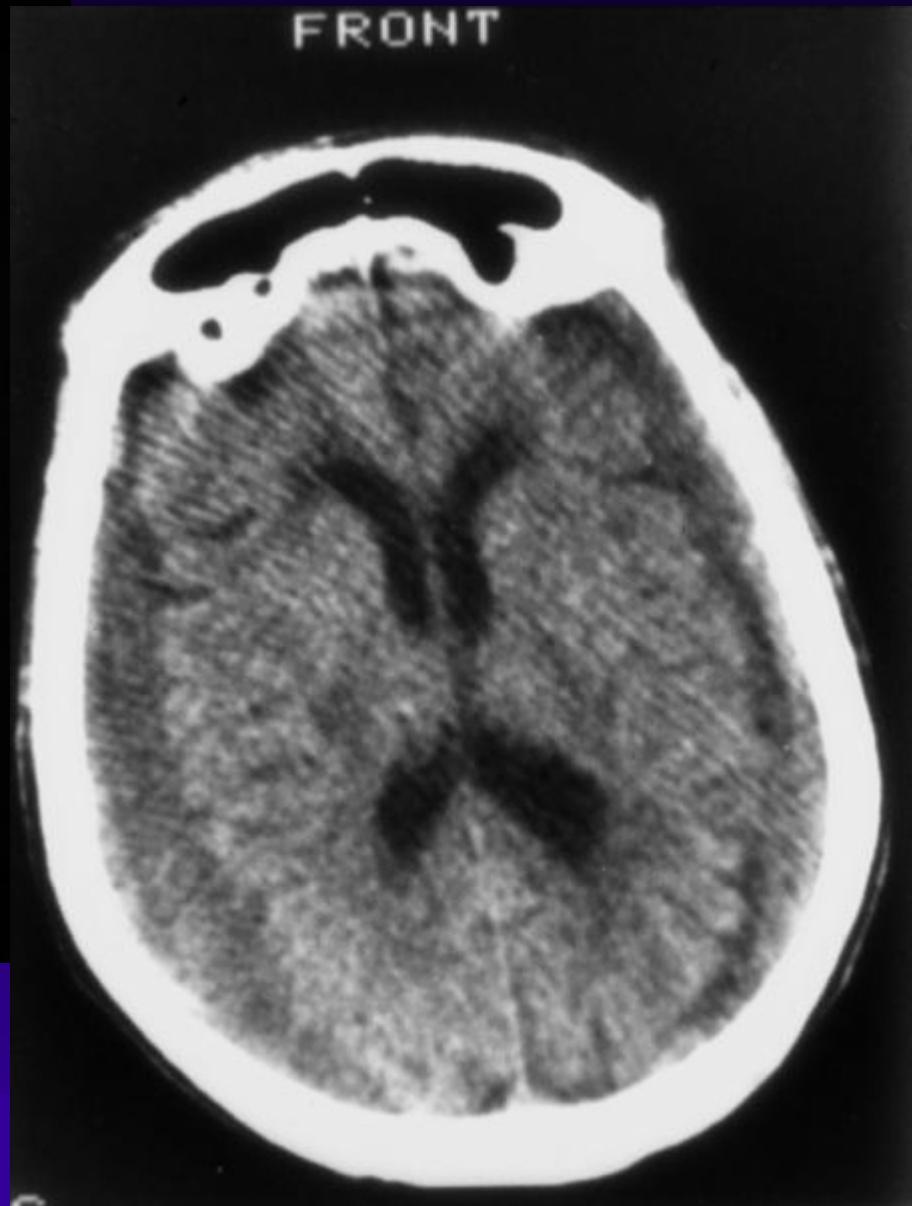
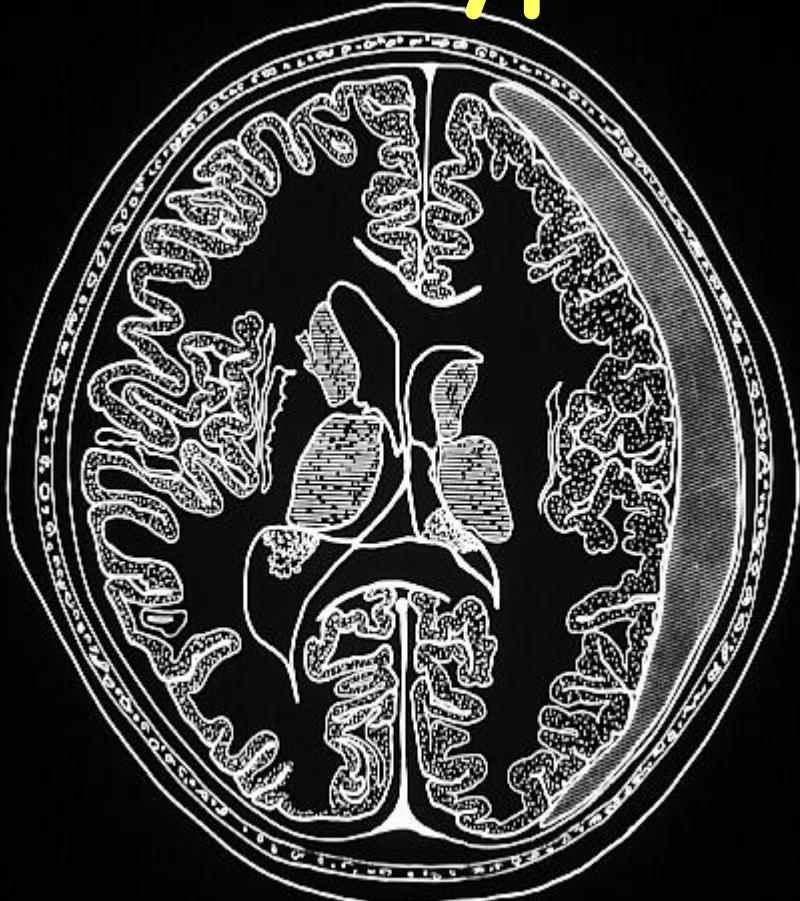
# Isodense subdural



Sulci



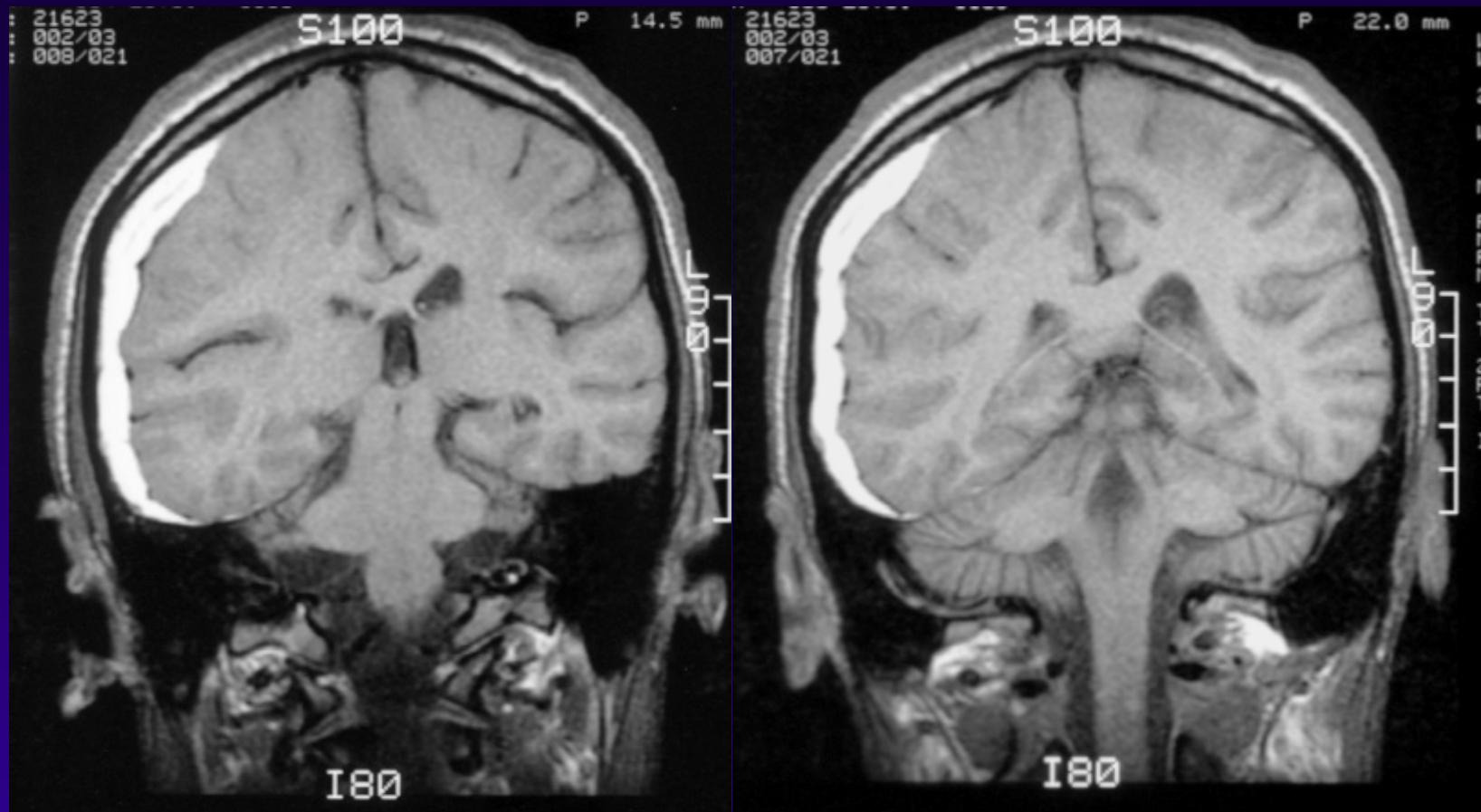
# Hypodense SDH



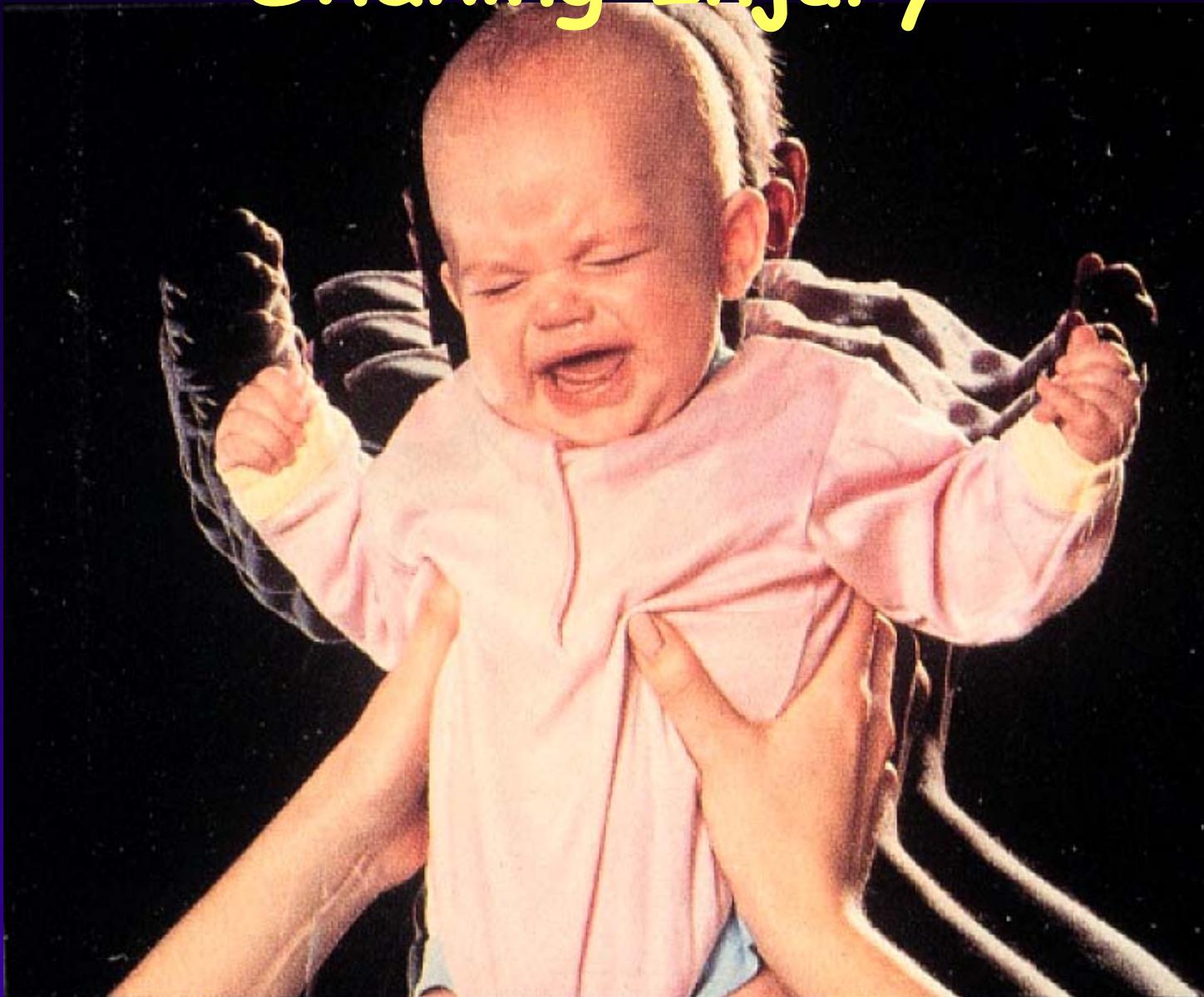
# SUBDURAL COLLECTIONS

- Acute SDH - hyperdense
- Subacute SDH - isodense
- Chronic SDH - hypodense
- Hygromas
  - Hypodense, isointense to CSF
  - CSF leak from arachnoid tears
- Effusions
  - Hypodense(meningo-encephalitis, esp. H.flu)

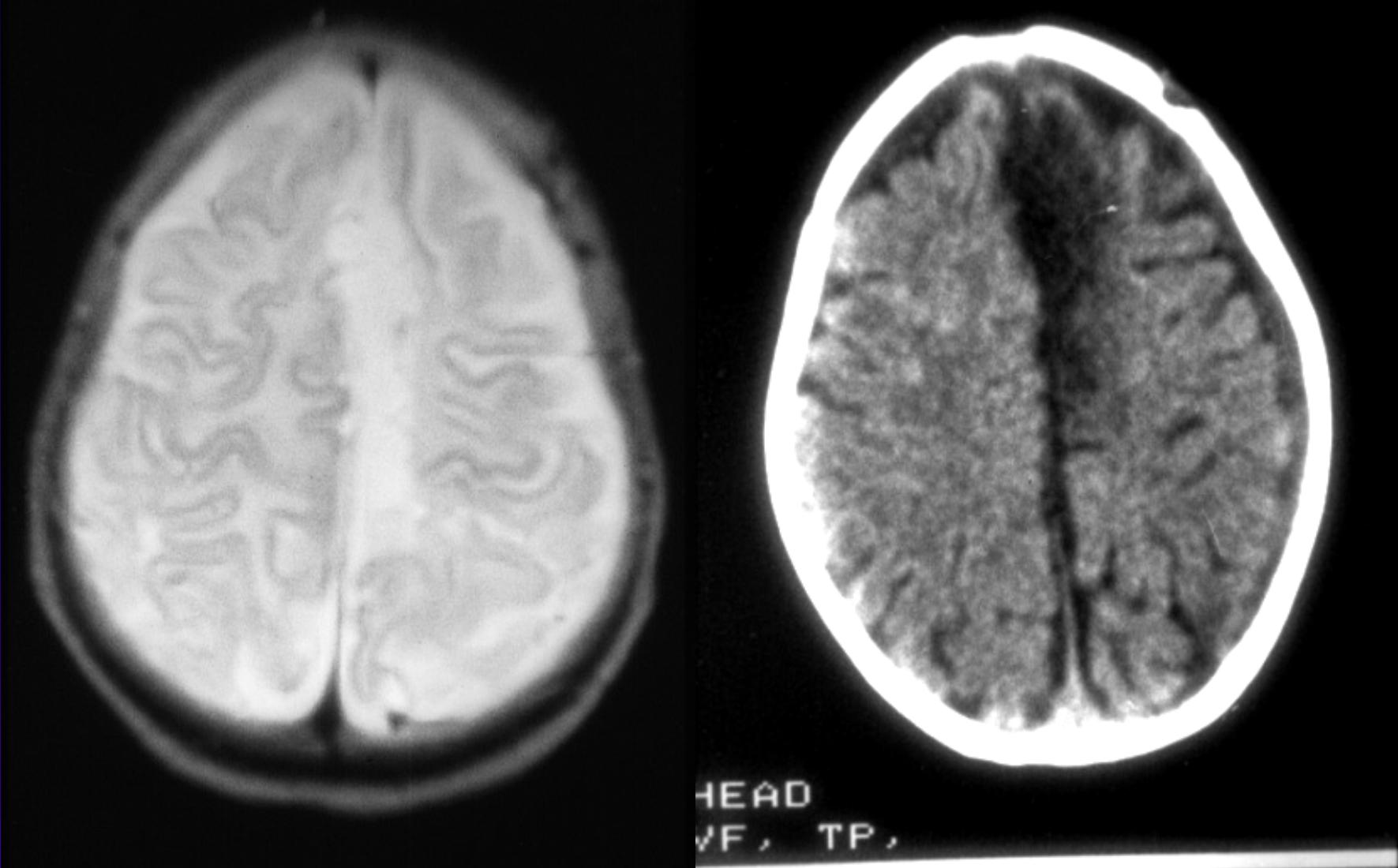
# Subdural Hematoma



# Shaking Injury

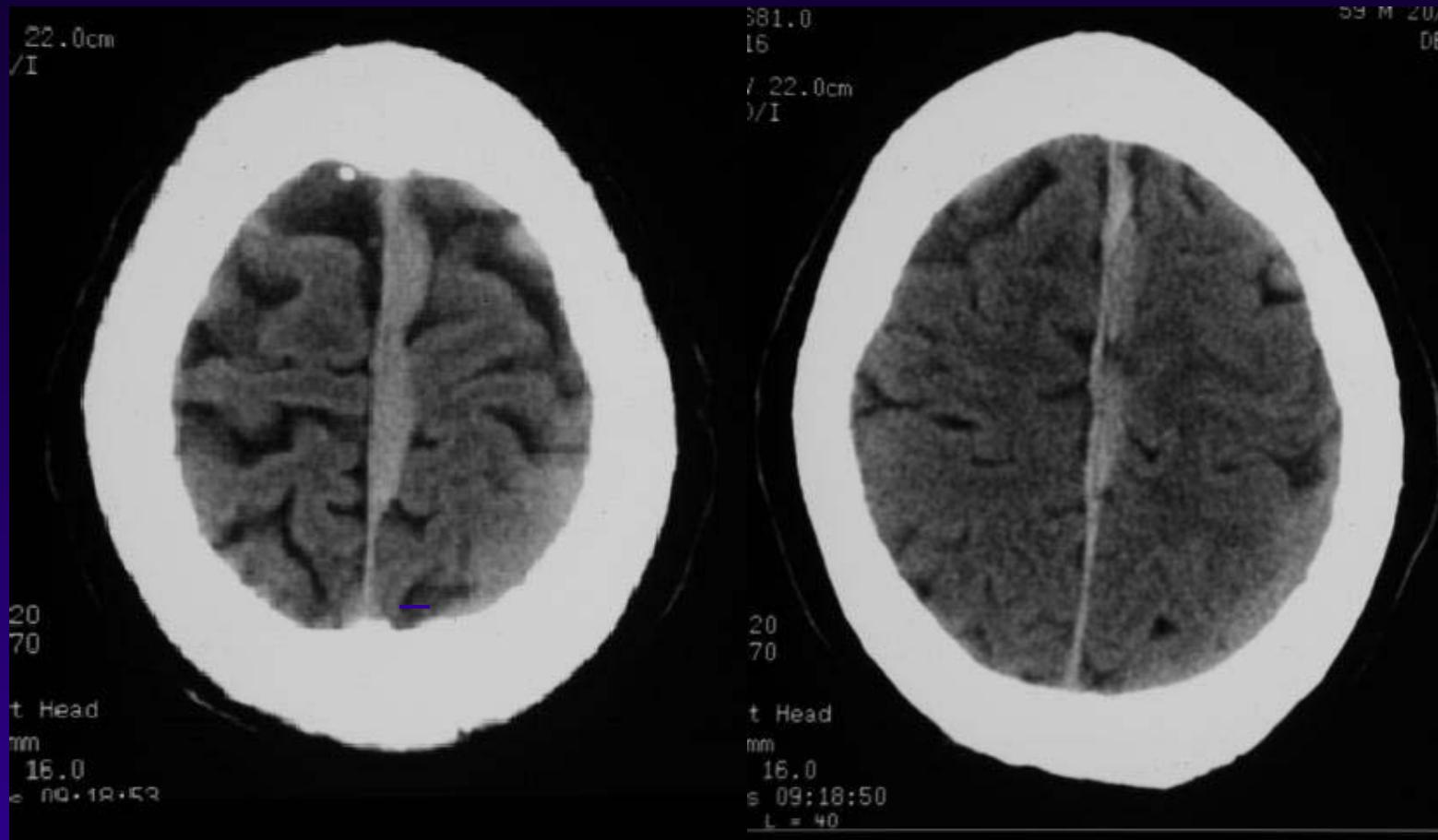


# Interhemispheric Subdural



HEAD  
VF, TP,

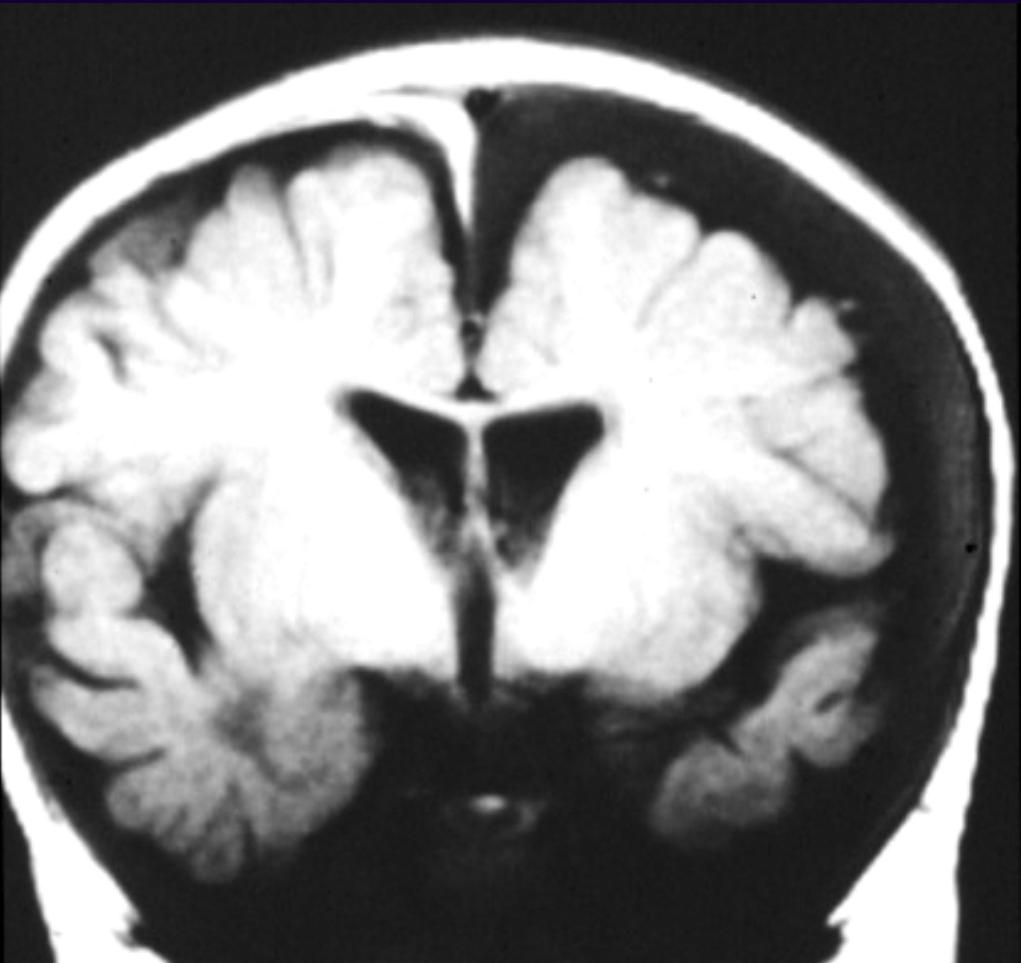
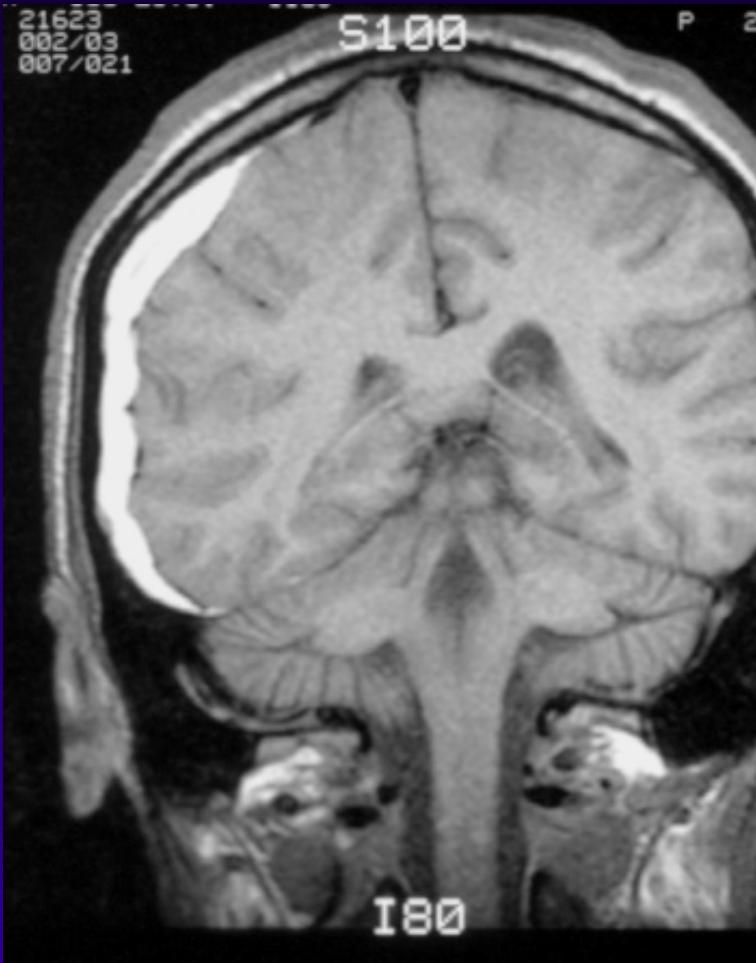
# Interhemispheric Subdural



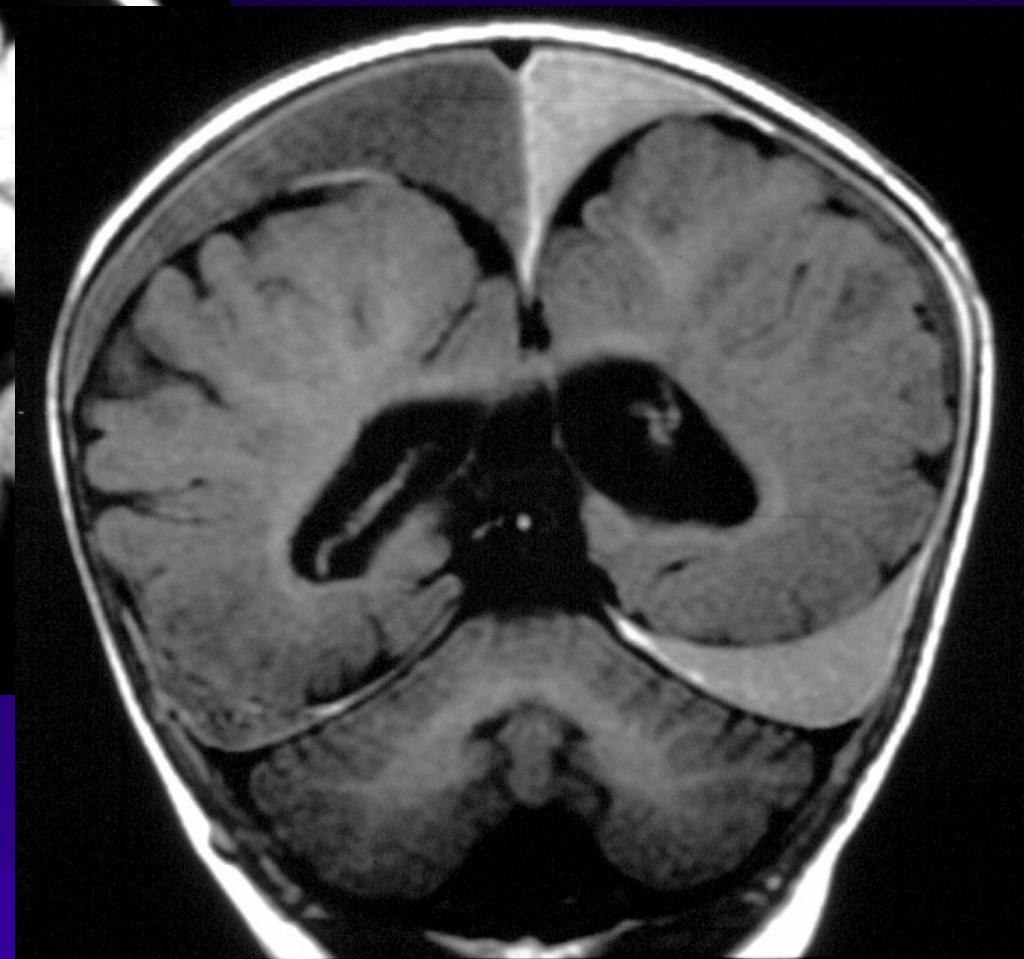
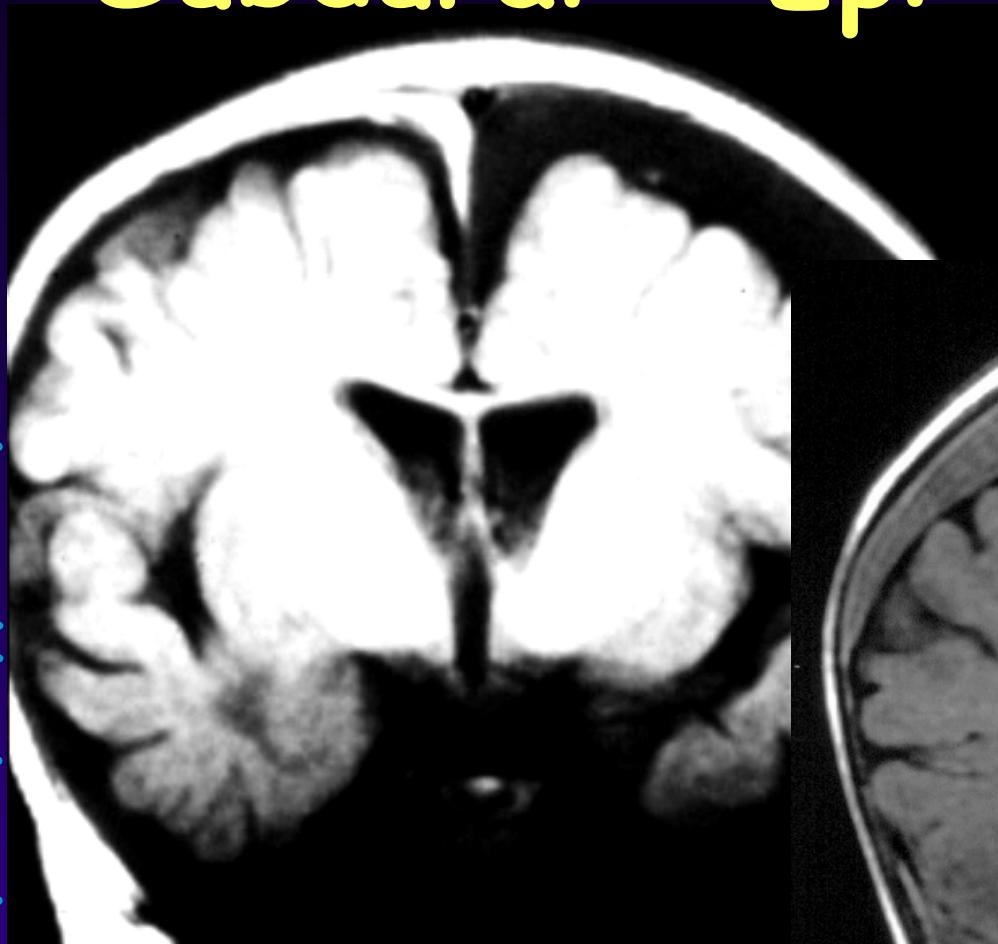
# INTERHEMISPHERIC FISSURE and the FALX SIGN

- Normal Falx:
  - thin white line, may see CSF parallel
- Subarachnoid Blood:
  - anterior, zig-zag, reaches the corpus
- Subdural Hematoma:
  - posterior, straight, doesn't touch the corpus callosum

# Subdural Hematoma



**Subdural = Epi - Arachnoid**



# SUBDURAL HEMATOMA

- 2-3 wks. to develop fully
- develop from outer (dural) margin
- not from arachnoid side
  - inner (arachnoid) border intact
- fibroblasts, and new immature capillaries that are fragile

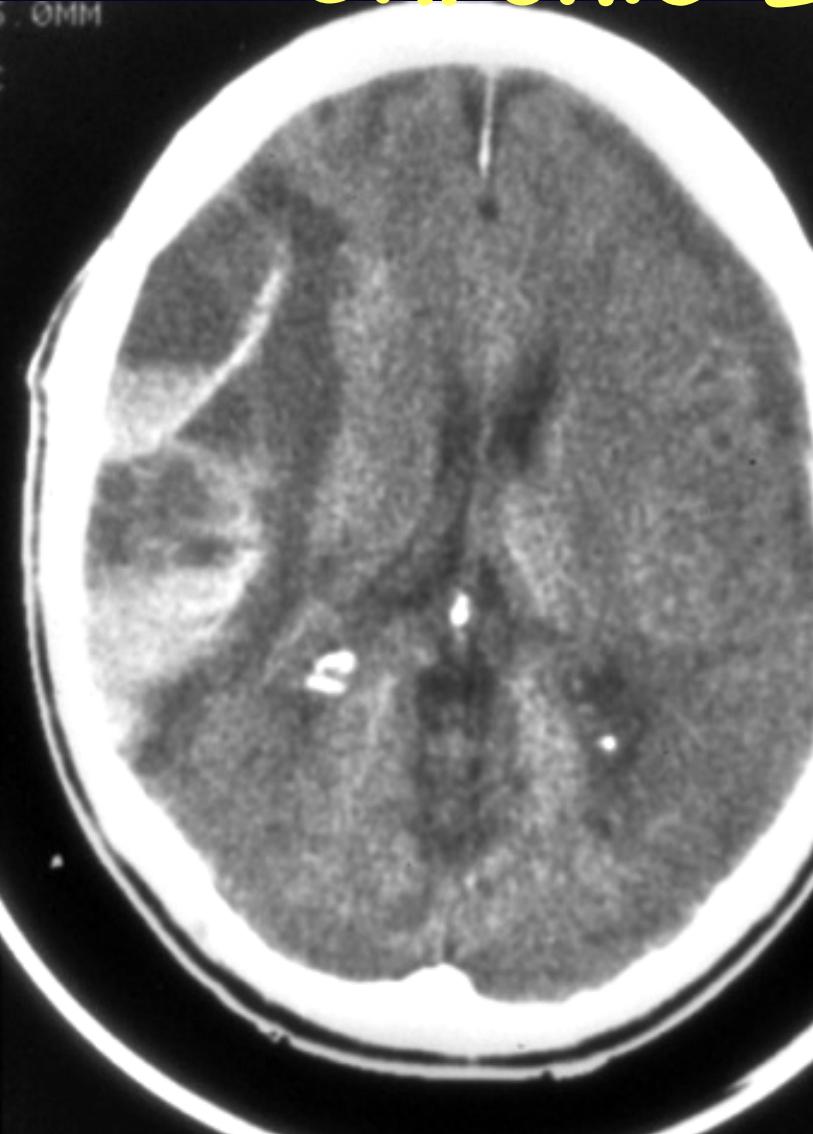
# Neomembrane from Dura



# SUBDURAL HEMATOMA - Source of Re-bleeding

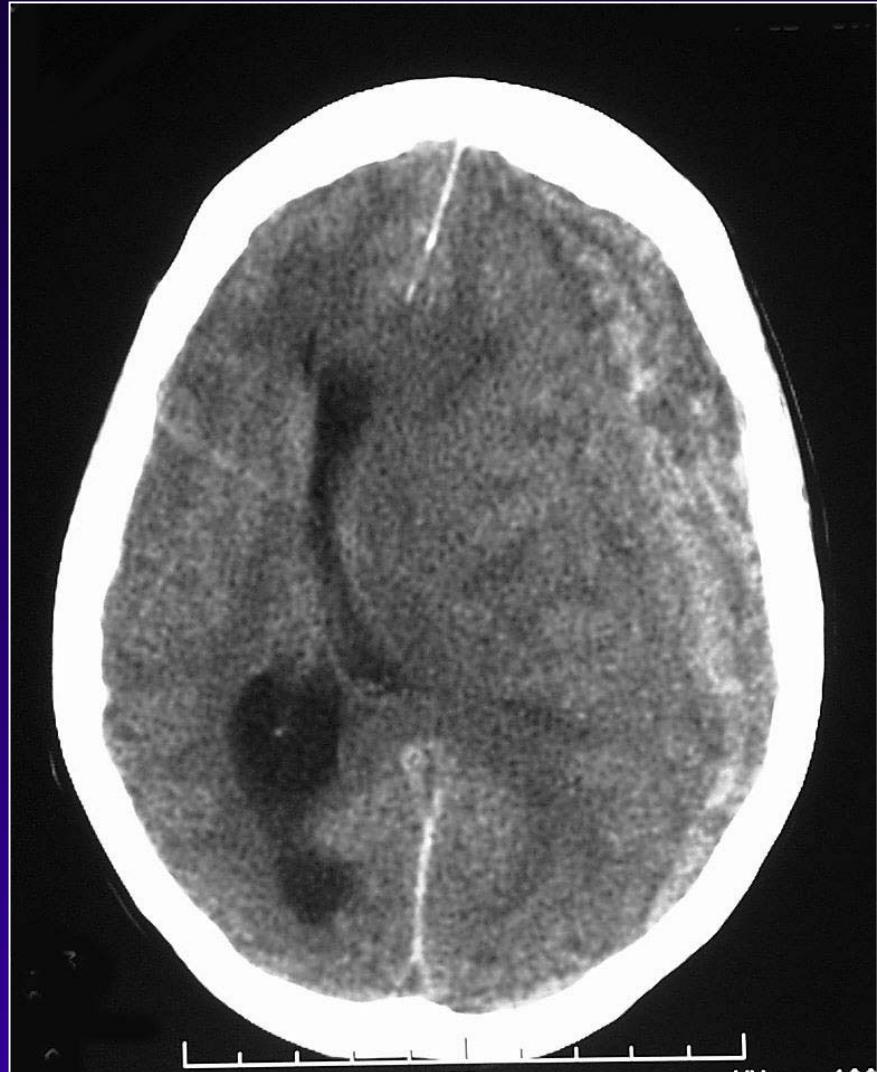
- NEO-MEMBRANES
  - fragile capillaries
- BRIDGING VEINS
  - stretching across SDH
  - constant tension

# Chronic Loculated SDH

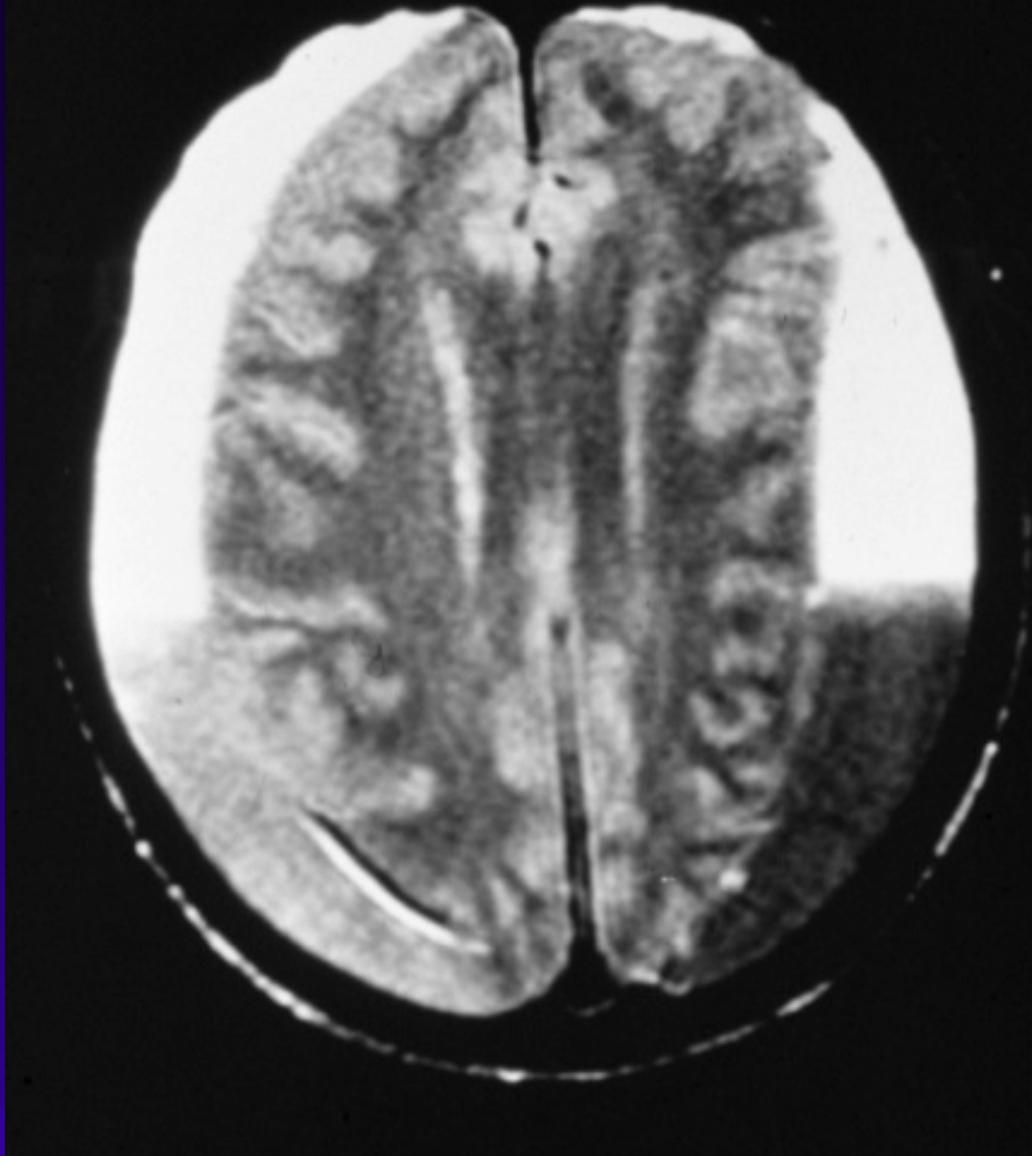


# Acute-subacute Subdural Hematoma

- Acute blood-bright
- Alternating bands
  - rebleeding
- Mass effect
  - Subfalcial herniation
  - “Trapped” ventricle



# Subdural Hematoma



# Subdural Hematoma

- Under the Dura
  - “Sub-Dural”
- Over the Arachnoid
  - “Epi-Arachnoid”
- Actually between the “Dural Border Cells”  
the “Arachnoid Barrier Layer”

# CEREBRAL CONTUSION

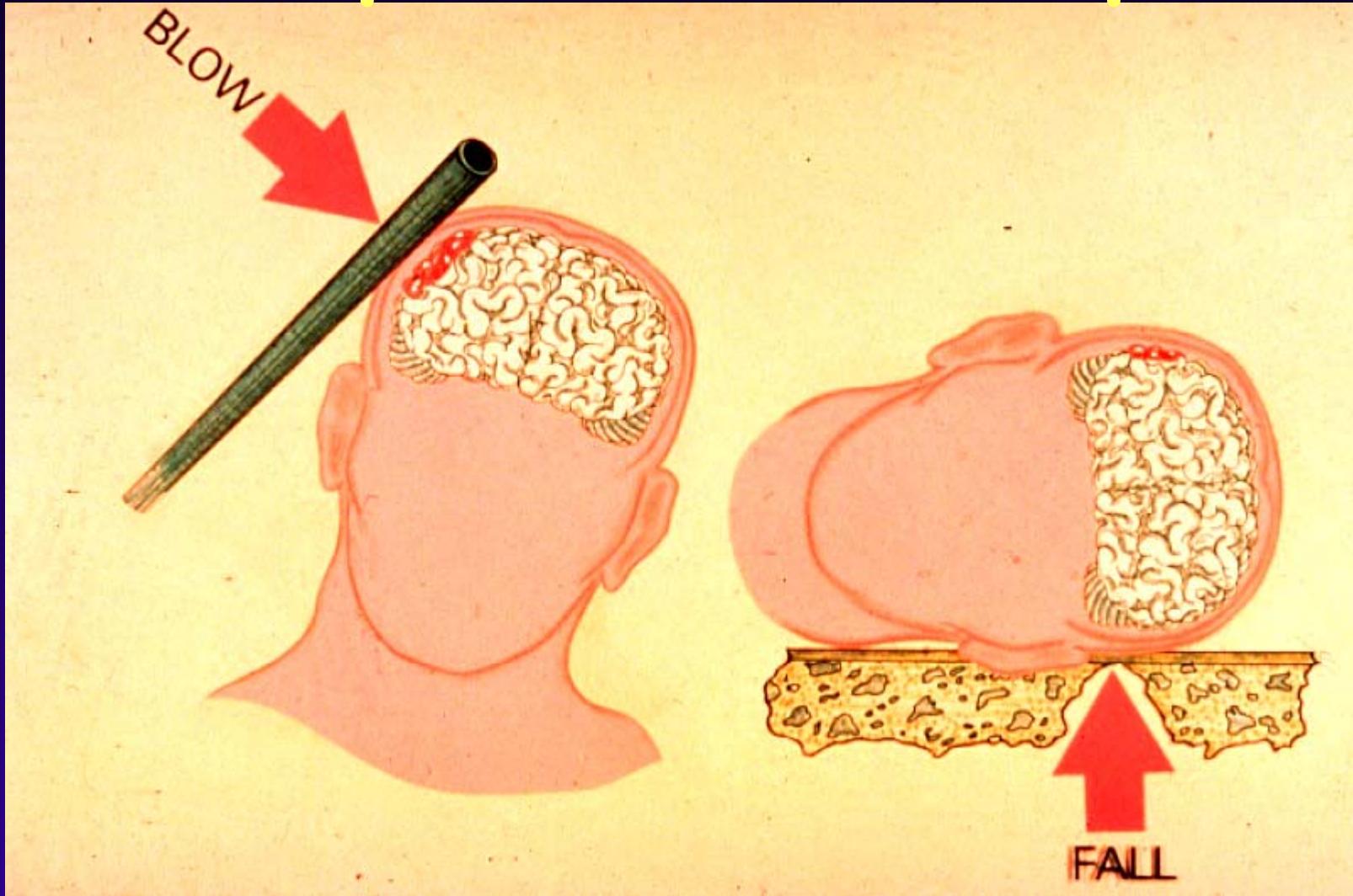
- Traumatic/mechanical disruption of small (capillary) vessels
- Extravasation of whole blood, plasma (edema) and RBC's
- Admixture of blood mixed with native tissue (petechial hemorrhage)
- Mottled / speckled density ("salt and pepper" on CT)

# CEREBRAL CONTUSION

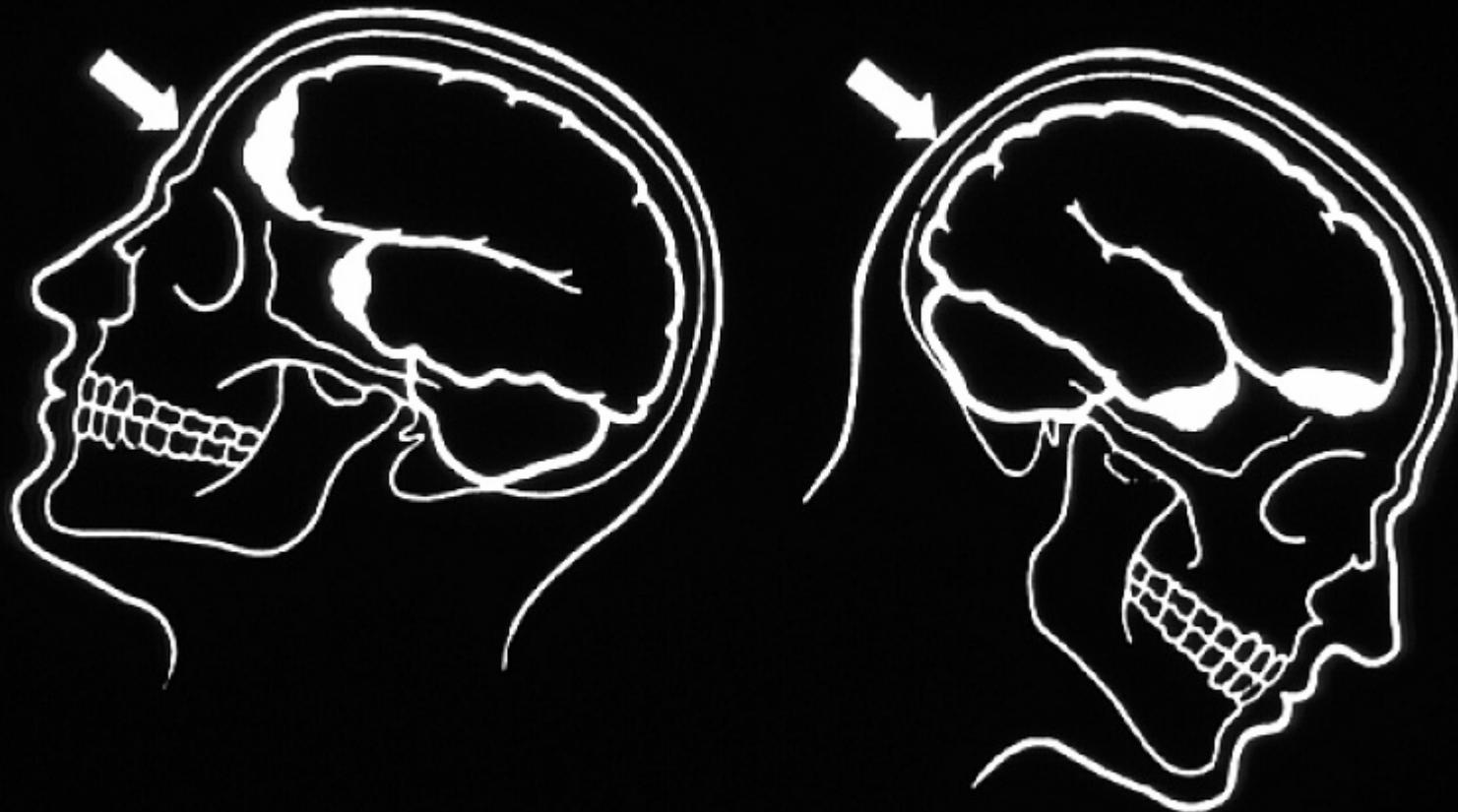
## (naming conventions)

- COUP (SAME SIDE AS IMPACT)
  - (w/fractures, small area of impact)
- INTERMEDIATE (CENTRAL)
  - (DAI/Shearing Injury)
- CONTRE - COUP (OPPOSITE IMPACT)
  - (w/falls, broad surface of impact)

# Coup vs. Contrecoup

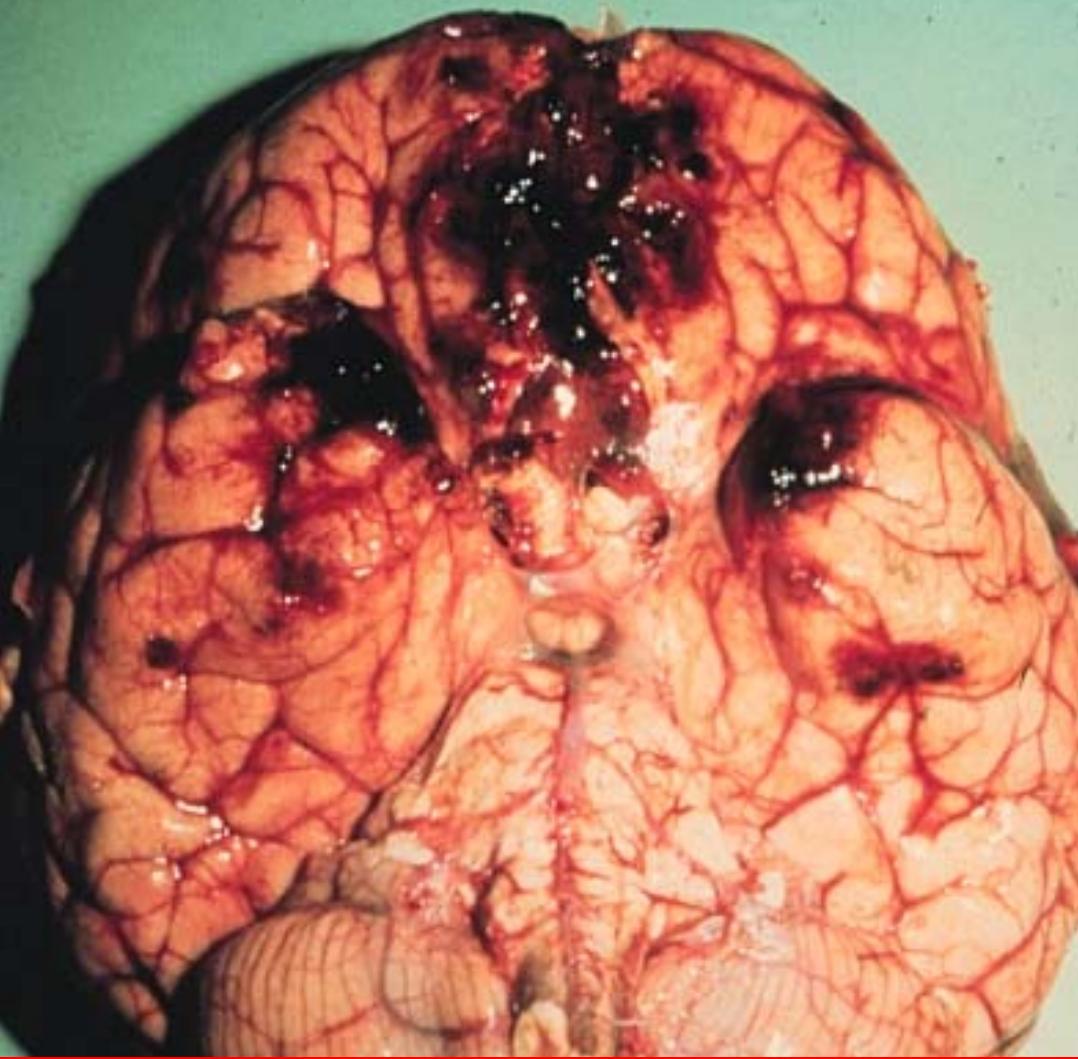


# Coup vs. Contrecoup



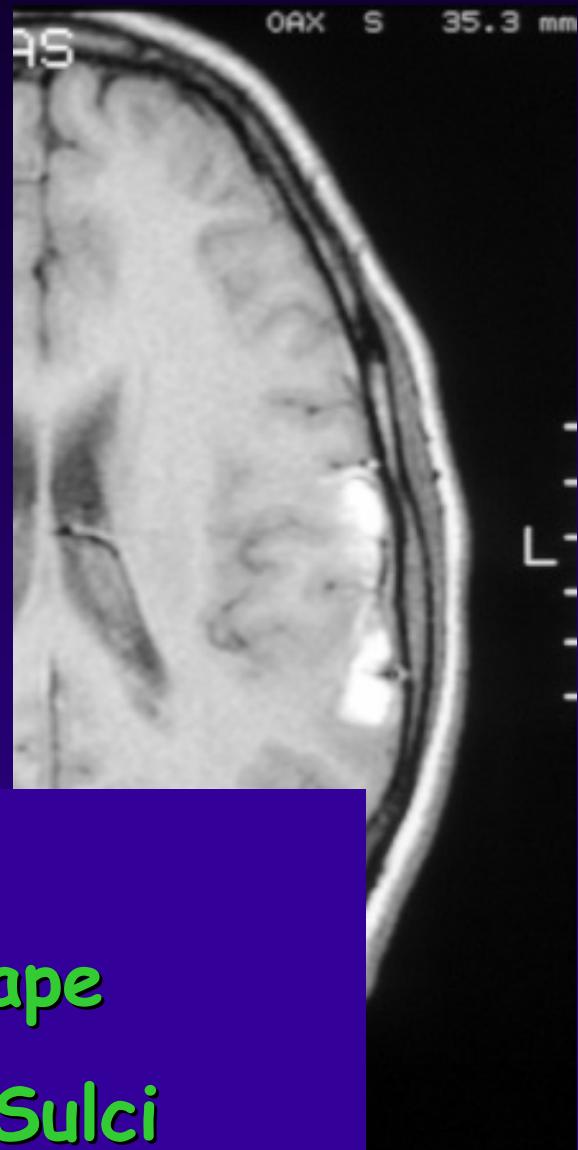
# CEREBRAL CONTUSION

- MECHANICAL INJURY TO VESSELS
  - Extravasation of whole blood
- PETECHIAL / PERIVASCULAR HEMORRHAGE
  - Admixture of tissue and blood
  - average density may NOT be high
- SWELLING/MASS EFFECT
- MAY PROGRESS TO HEMATOMA
  - If larger vessels are damaged
  - large confluent mass of blood



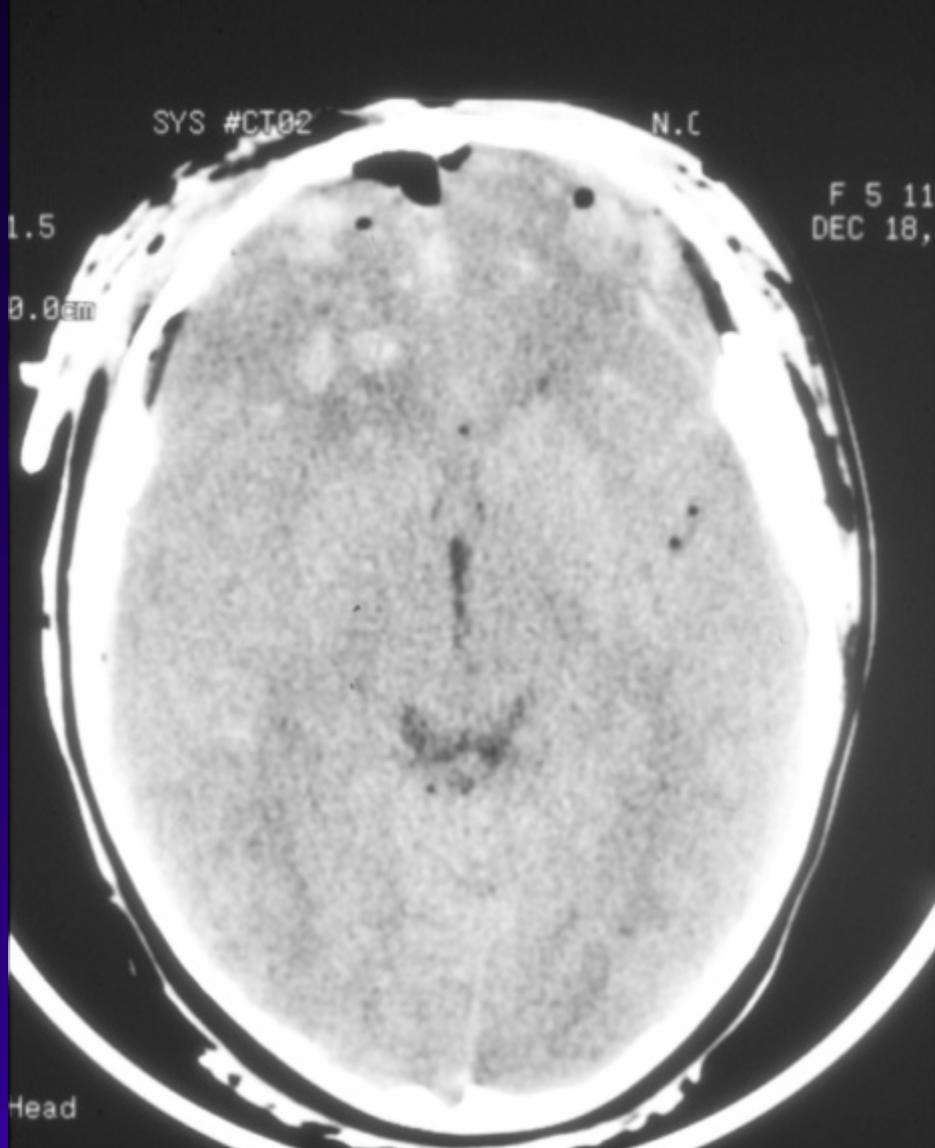
Temporal Tips  
Orbitofrontal Gyri

# Cerebral Cortical Contusion

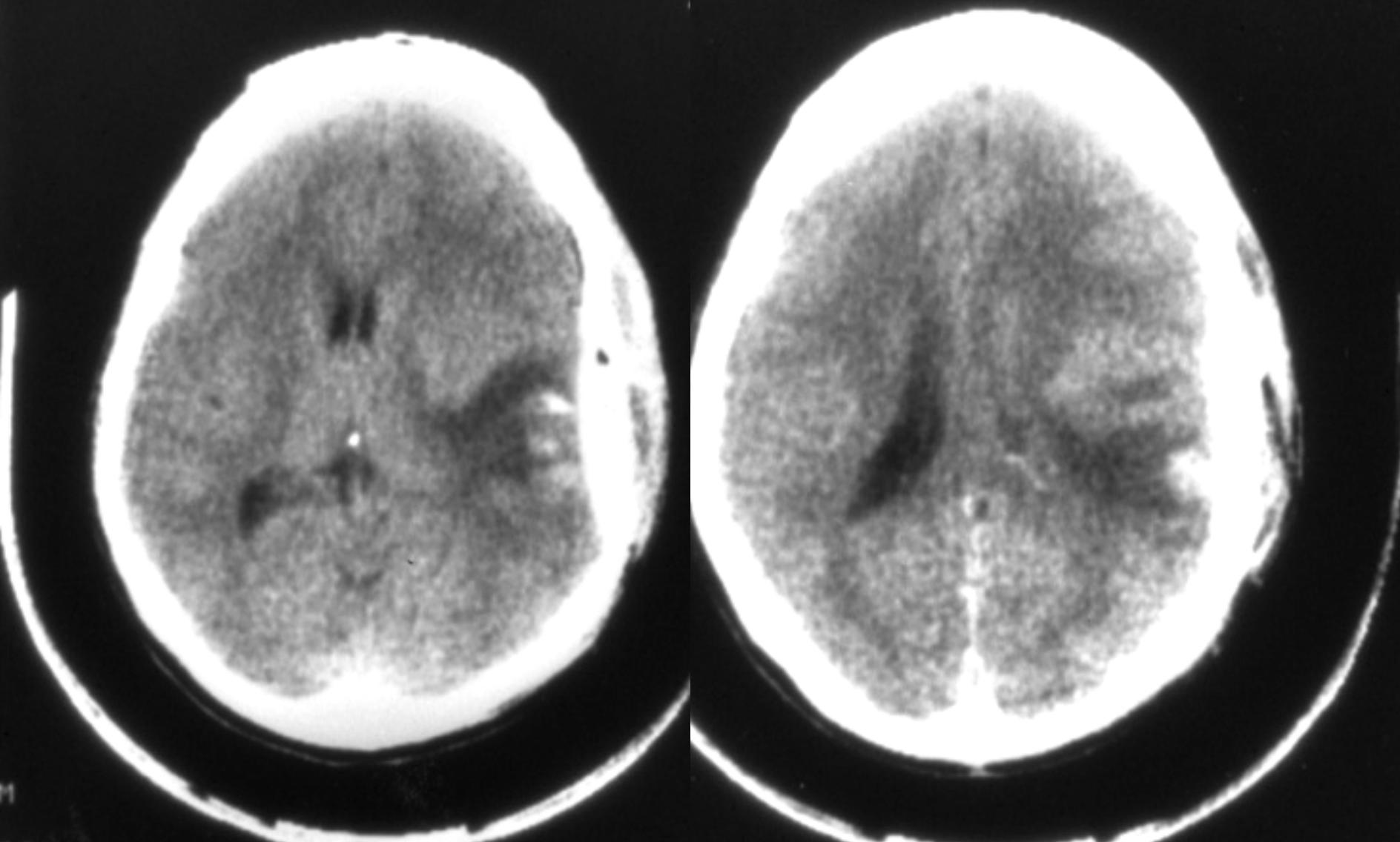


- Crowns of Gyri
- Linear or flame shape
- NOT in depths of Sulci

# Cerebral Contusion



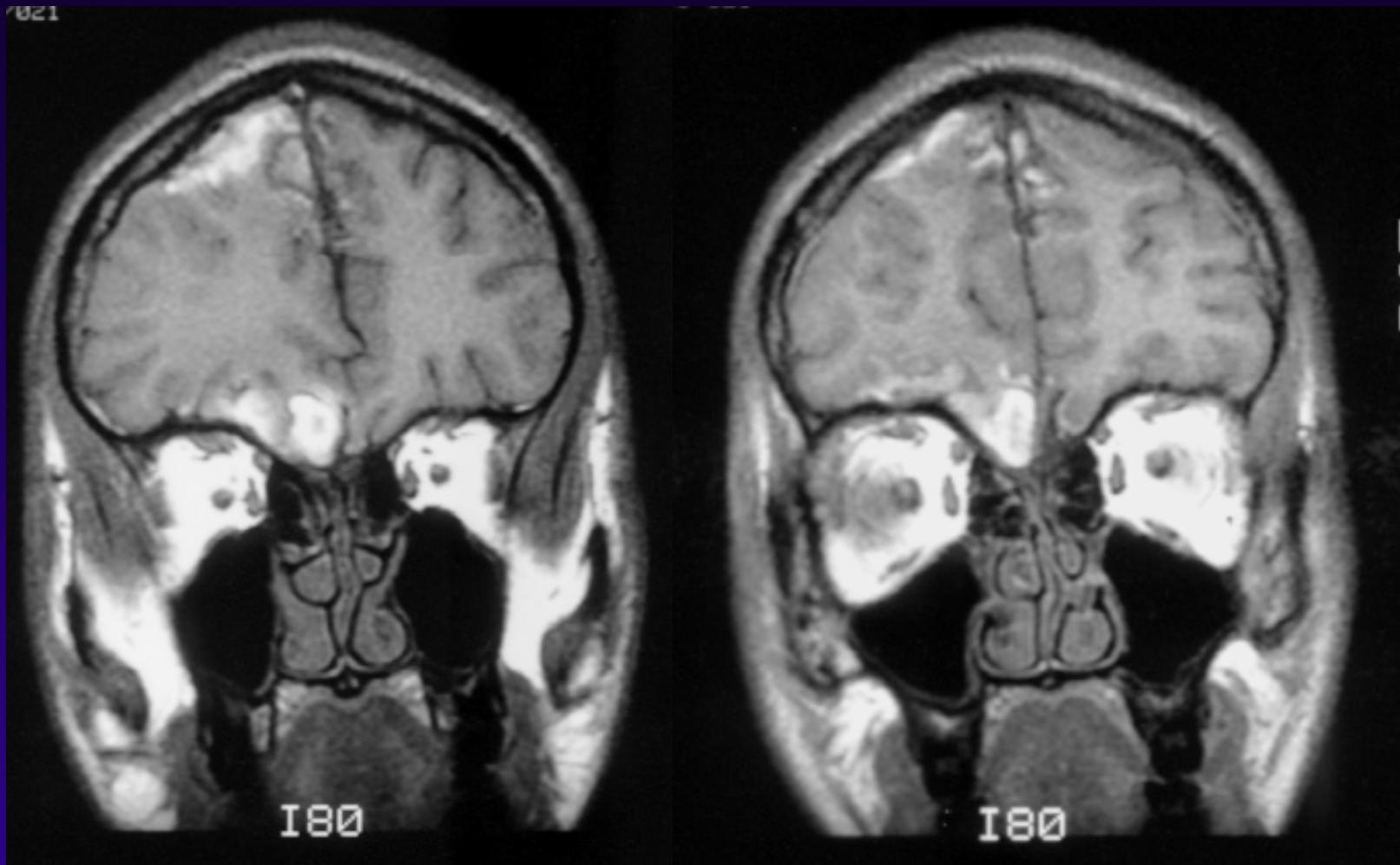
# Cerebral Contusion



# CEREBRAL CONTUSION

- CT Hypodense (EDEMA)
  - Isodense (mass)
  - Hyperdense(mottled, speckled)
- MR Variable Intensity
  - (GRE) - Hypointense
  - Hyperacute Blood
- COUP CONTUSION
  - ASSOCIATED w/Fx

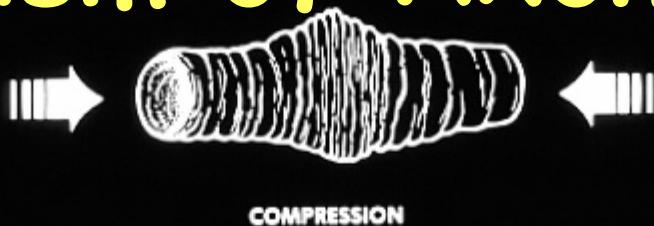
# Cerebral Contusion



# Deep Lesions - Terminology

- Intermediate Contusions
- Shearing Injury
- Diffuse White-matter Injury (DWI)
- Diffuse Axonal Injury (DAI)

# Mechanism of Axon Injury



# SHEARING INJURIES

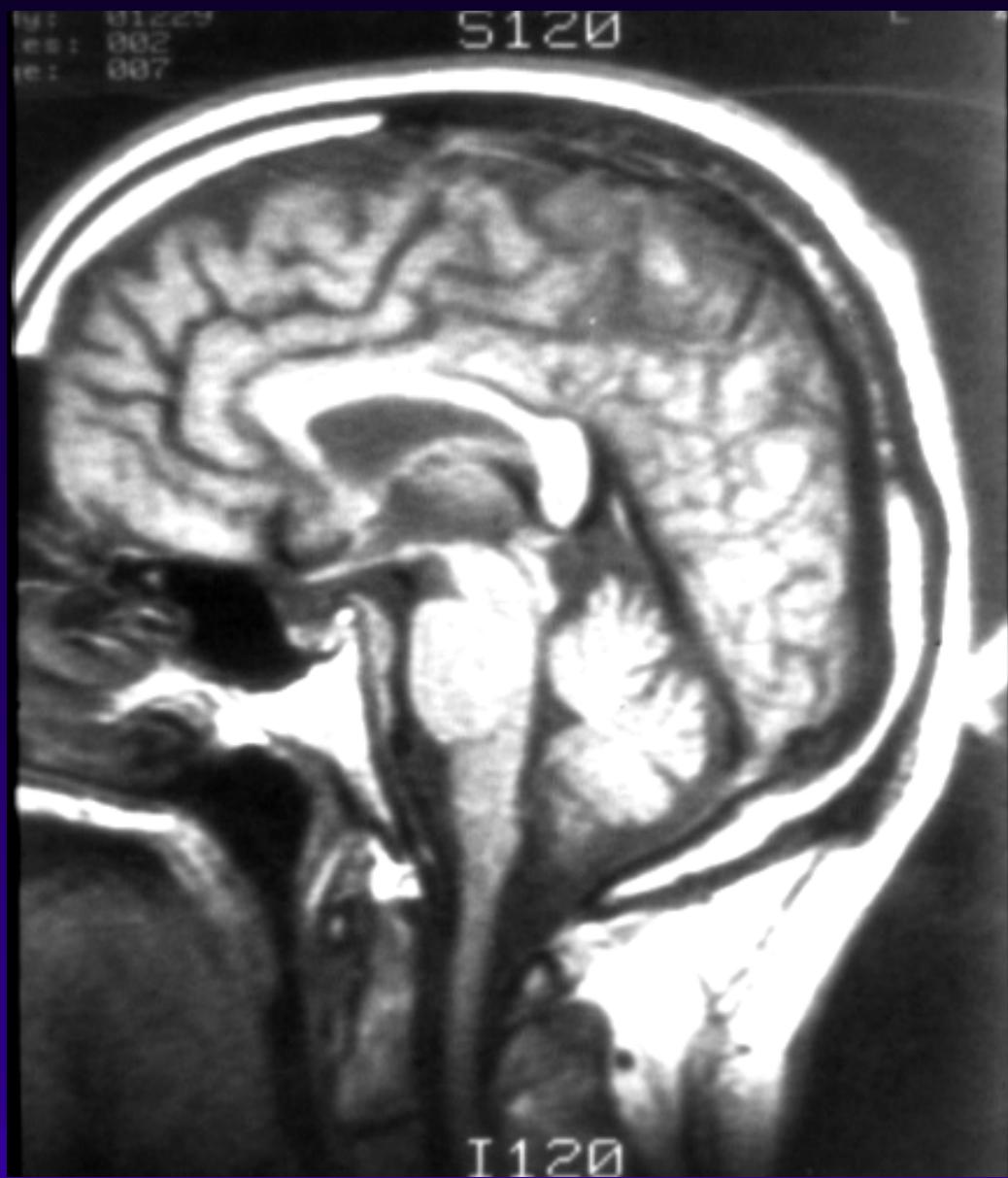
- Deep lesions
- High Velocity (MVA) Trauma
- Acceleration/Deceleration
- Do not require an impact or Fx
- SHEARING OF AXONS
  - Breaks connections
  - Actual force may be tension
- SHEARING of Small WM VESSELS
  - Small (petechial) hemorrhages

# Deep Lesions

- Subcortical and Hemispheric WM
- Corpus Callosum
  - posterior body
  - splenium
- Brain stem
  - Dorsolateral Quadrant of Upper BS
  - Deep BS
  - Ventral BS

# DIFFUSE AXONAL INJURY

- Immediate L.O.C. Persistent Vegetative State
- Pathology:
  - foci of hemorrhage in callosum, brainstem, etc.
  - axon retraction balls (ARB)
- Long-Term Survivors:
  - microglial clusters
  - foci of demyelination





<http://rad.usuhs.mil>



<http://rad.usuhs.mil>

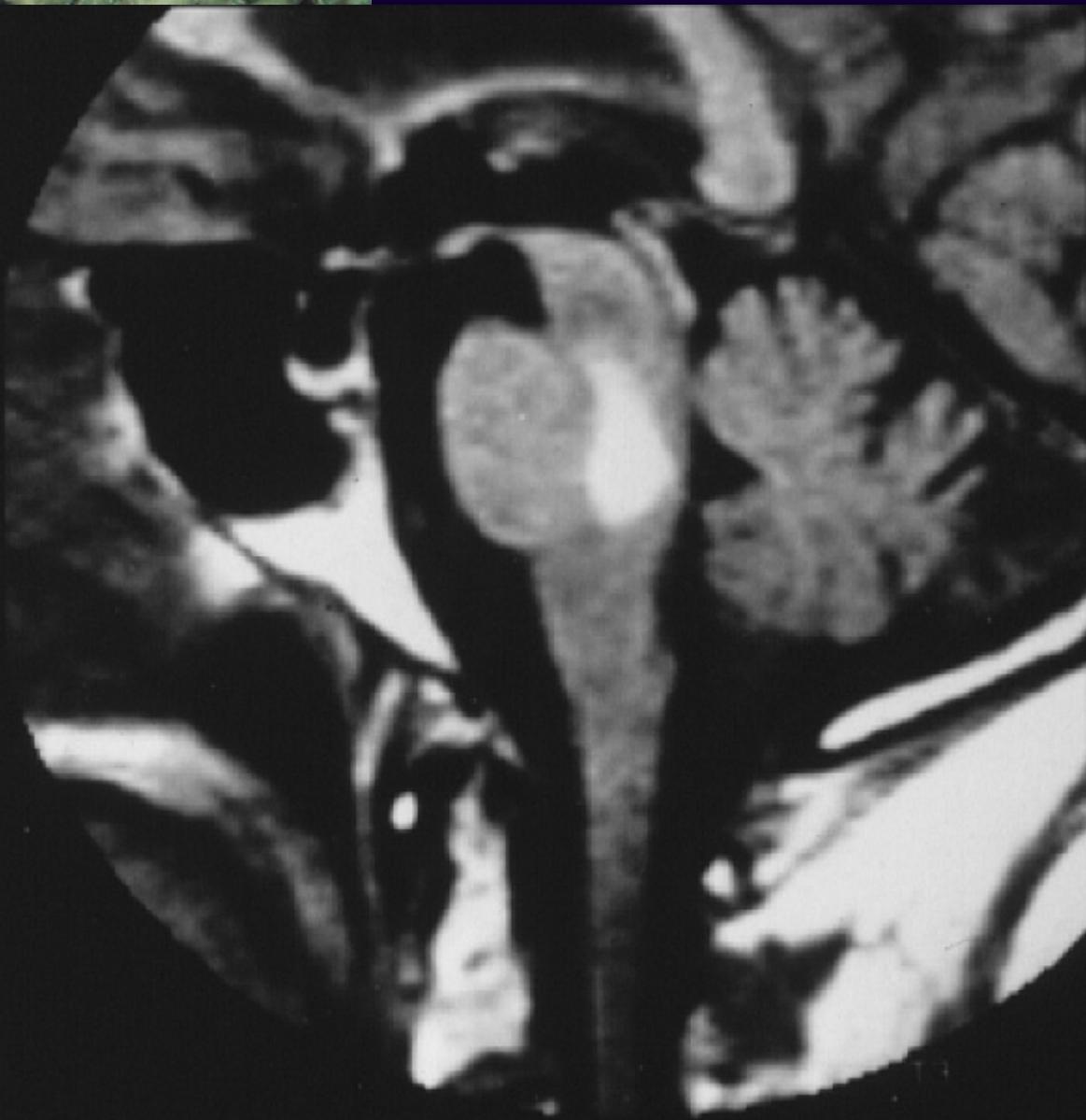
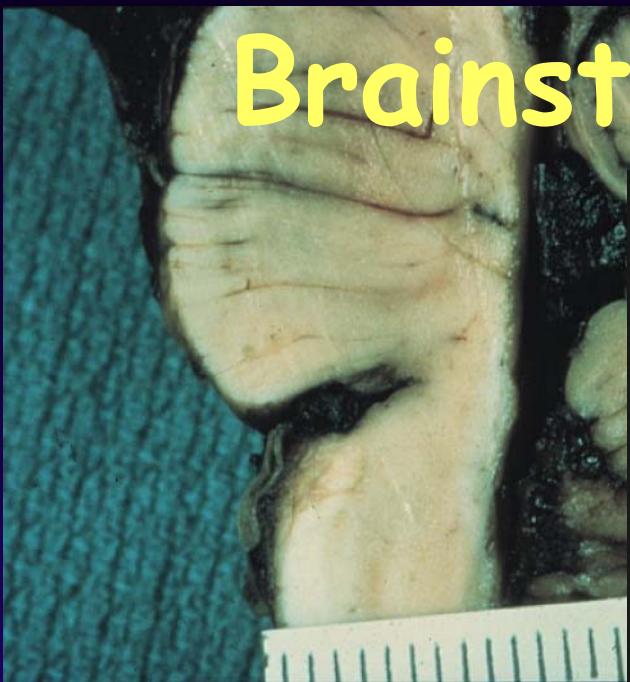


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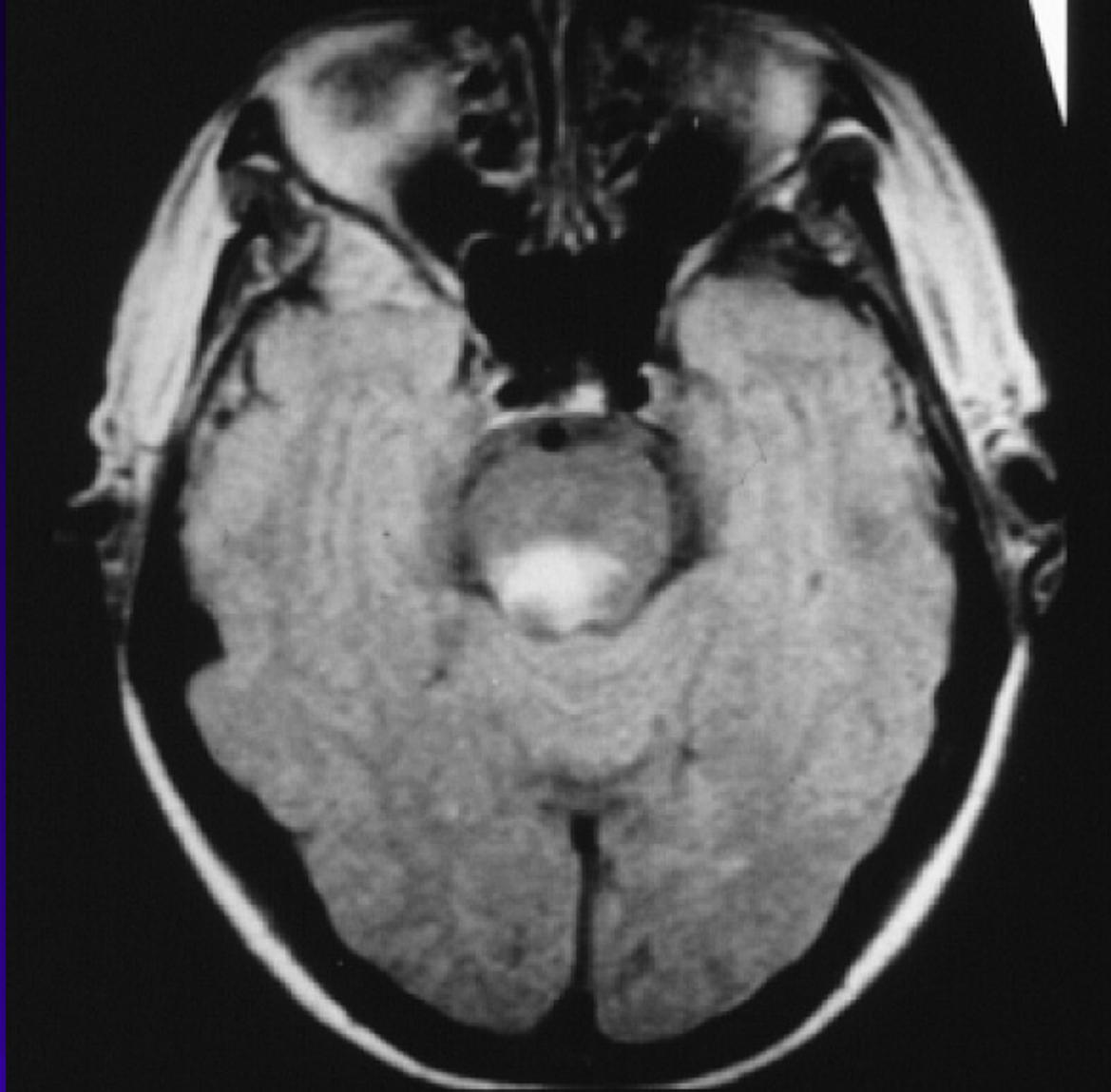
# Pontomedullary Tear



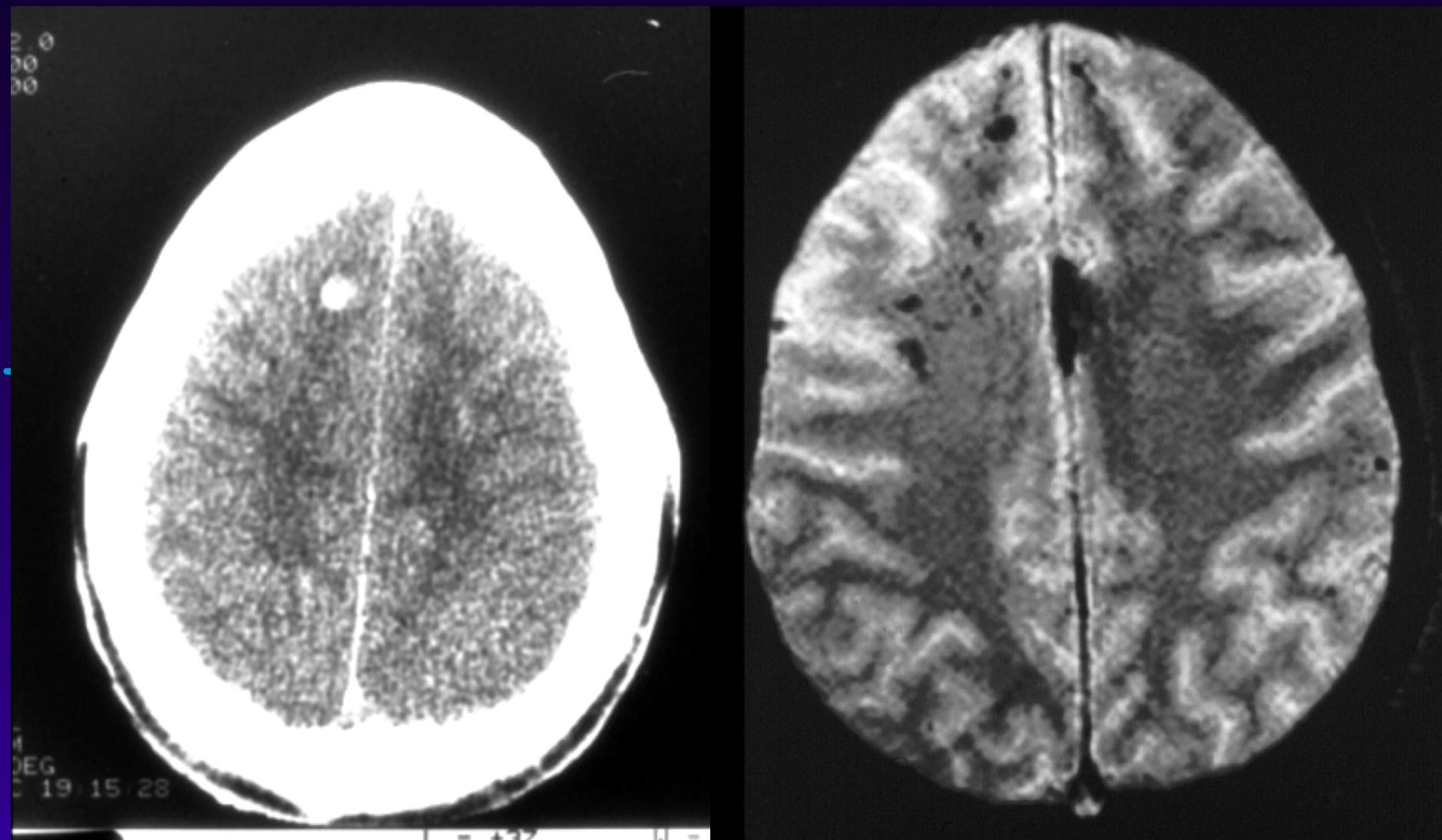
# Brainstem Hemorrhage



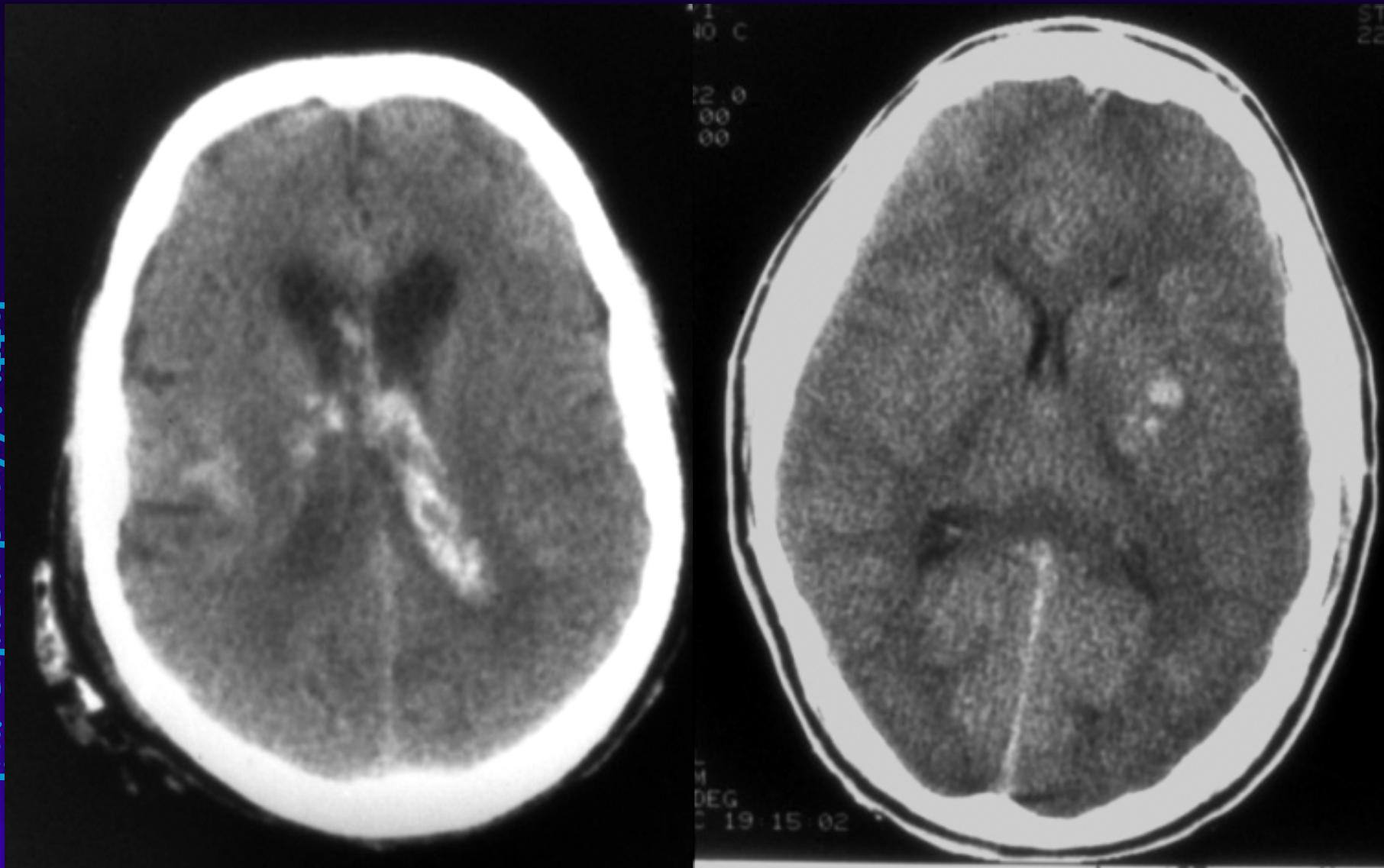
# Dorsolateral Brainstem



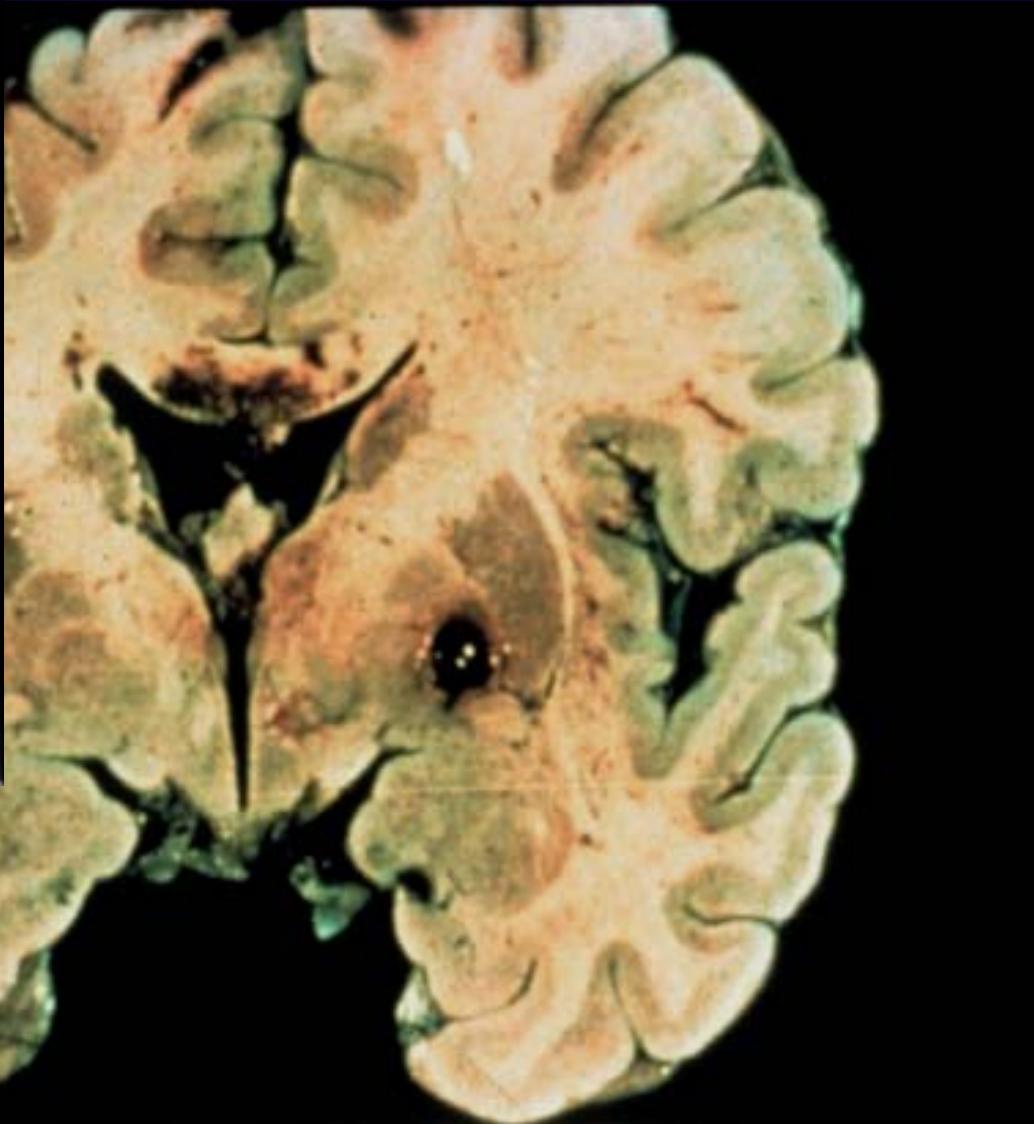
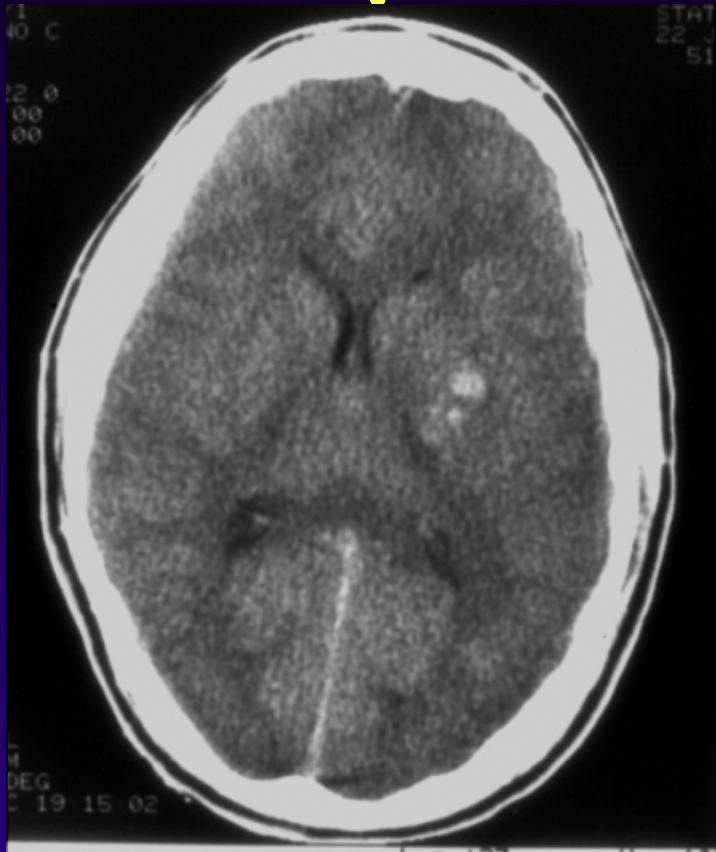
# CT vs. MR (GRE)



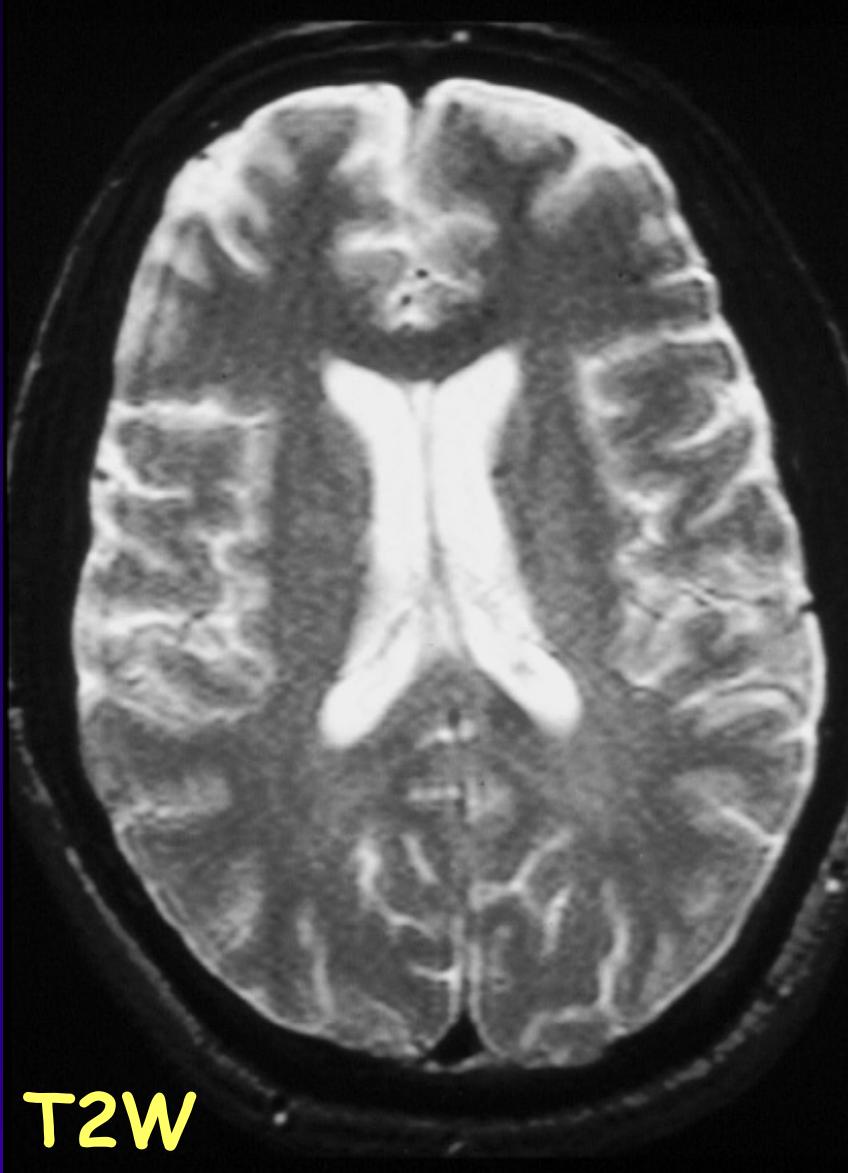
# Corpus Callosum -> Ventricle



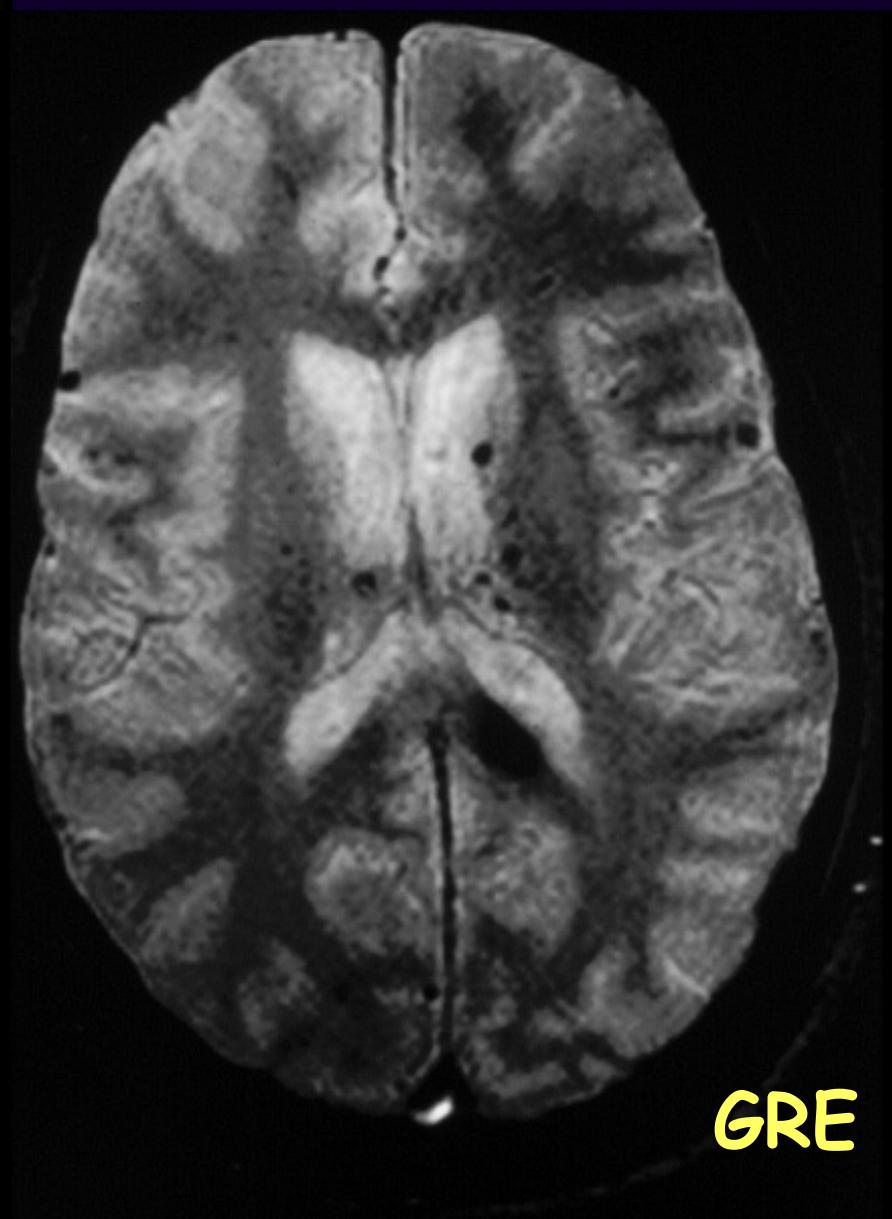
# Corpus Callosum and BG



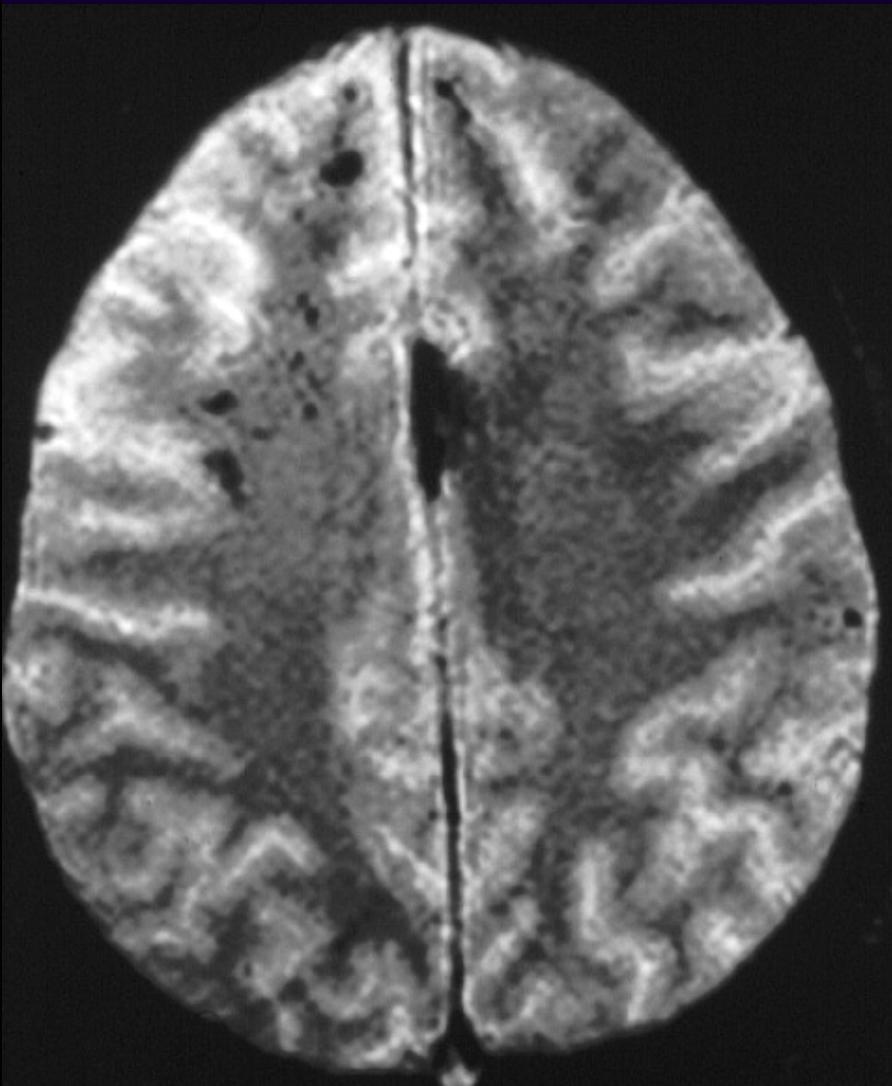
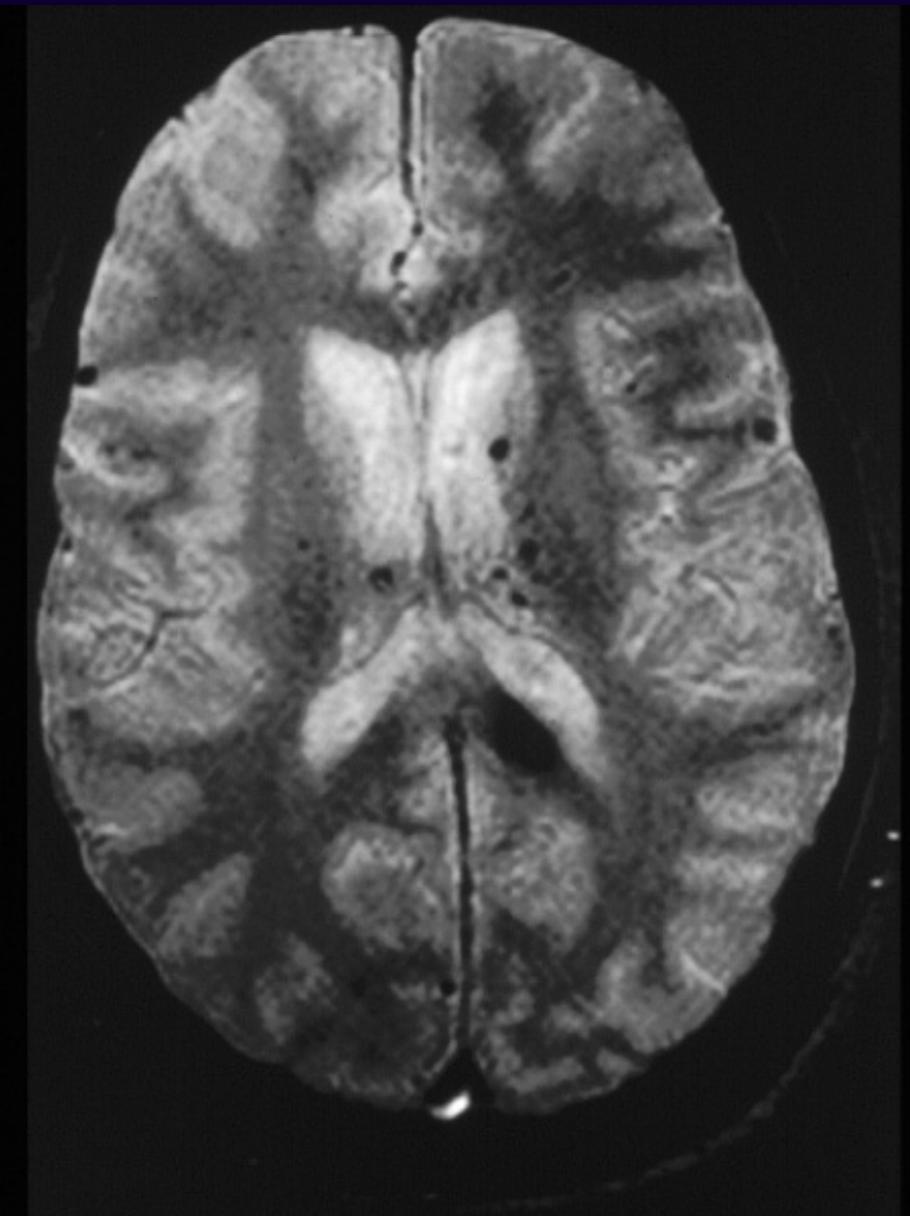
# T2W vs.. GRE (Gradient Recalled Echo)



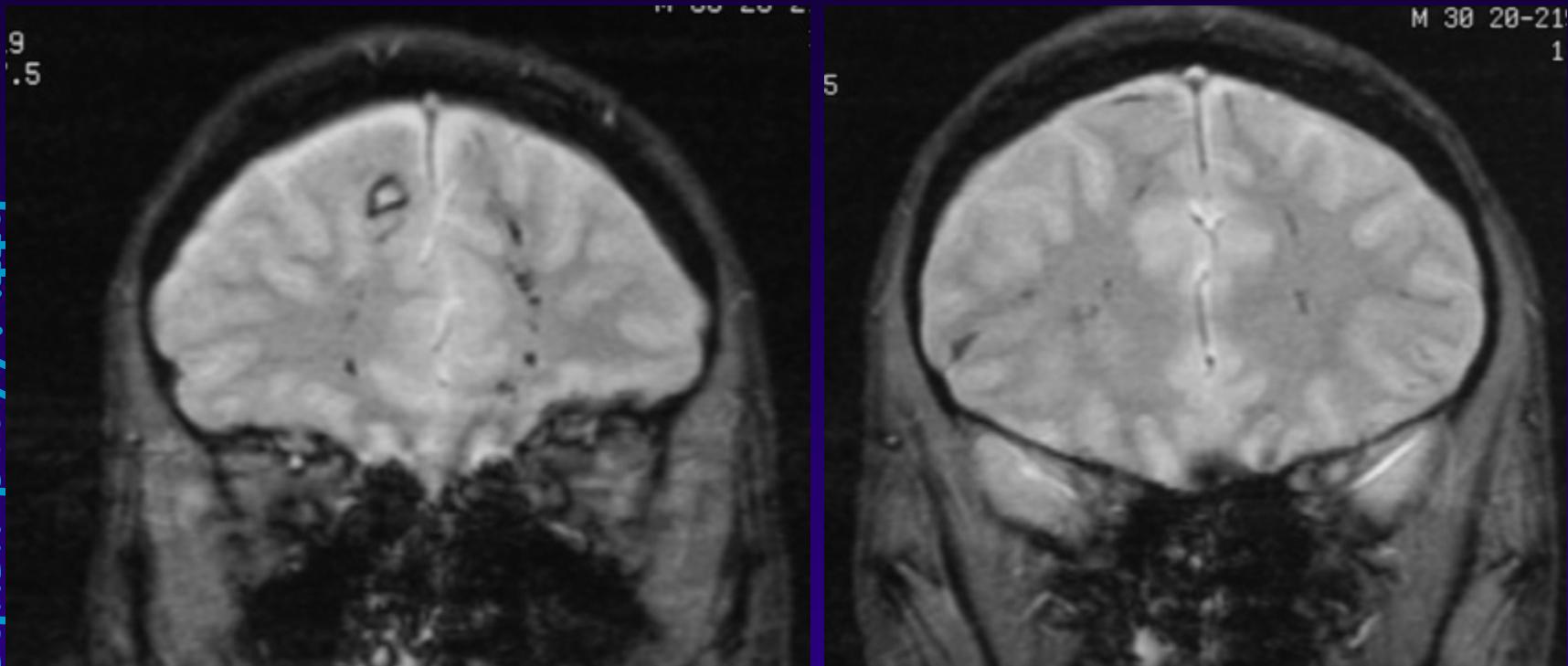
T2W



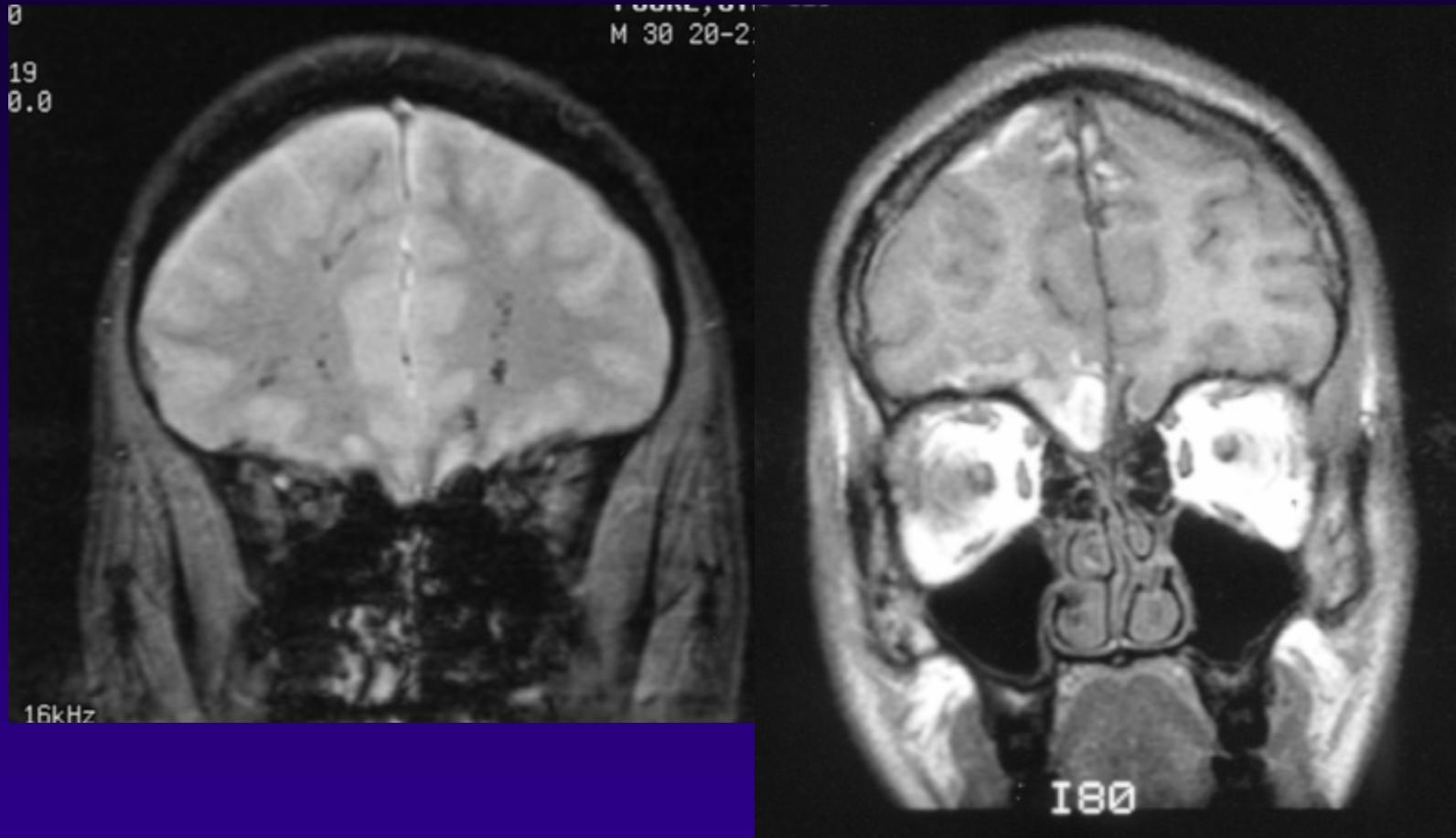
GRE



# Shearing Injury - Deep Lesions



# Shearing Injury vs. Contusion



# CNS TRAUMA - Summary



- Epidural Hematoma (subperiosteal)
  - acute, convex, white
- Subdural hematoma (epi-arachnoid)
  - variable shape, density, age
- Contusion (petechial)
  - Surface - cortex. coup/contra
  - Dark on GRE - CT "speckled"
- Shearing injury (DAI)
  - Deep - subcortical WM, corpus callosum and & basal ganglia

# The End

# Mil Gracias !



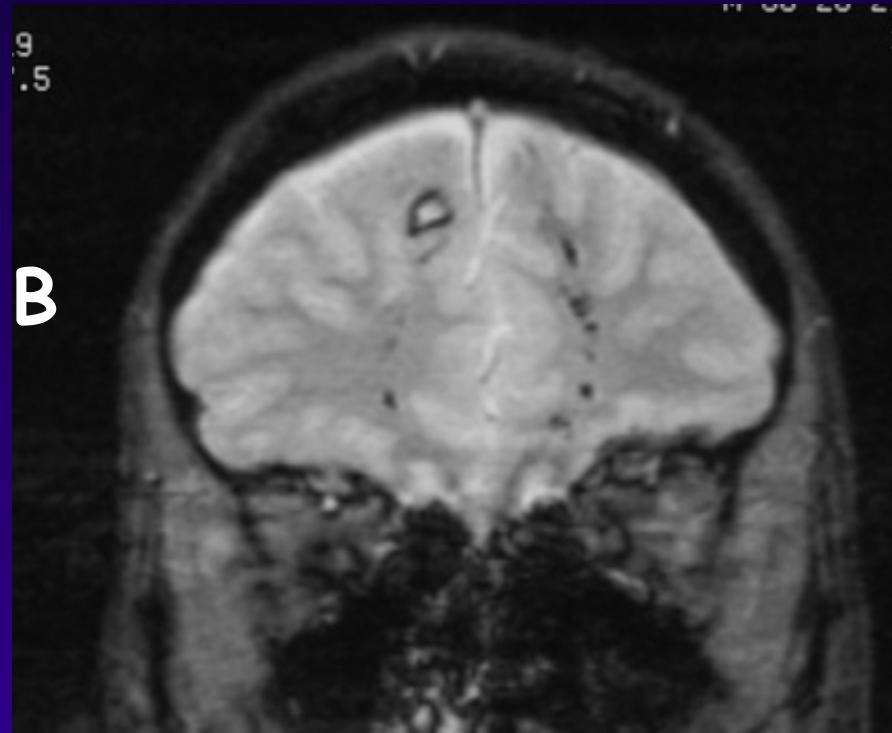
# Trauma Quiz

- 1. This image is most consistent with:
  - A. Acute SDH
  - B. Chronic SDH
  - C. Rebleeding SDH
  - D. Epidural
  - E. Shearing injury



# Trauma Quiz

- 2. Deep lesions like this are due to:
  - A. Contusions
  - B. Hematomas
  - C. Shearing
  - D. Both A and B
  - E. A, B, and C



# Trauma Quiz

- Which of the following are TRUE?
- 3. This is a depressed skull Fx
- 4. This is a pattern injury
- 5. The skull Fx in Compression



# Trauma Quiz

# Trauma Quiz

# Trauma Quiz

<http://rad.usuhs.mil>

## Learning to Care for Those in Harm's Way

SPEED  
BUMPS

West Ave STAFF PARKING

All Workers Report  
To Security Office

5

.5MM

DOE, JO  
25 N

1  
20  
320.00

# Slides to Add

- Penetrating Trauma
- Ax Slides
- Eyeball Slide
- Golf Club Slide
- Spaghetti Slide
- SDH vs. SAH Coronal MRI